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ELIAS HOWE, JUN.

ORIGIN OF THE SEWING MACHINE.

NOW that the sewing machine has become one of the most common and indispensable requirements of our modern civilization, it seems only strange that it was not thought out and perfected at a very much earlier date. Before the invention of printing, or the discovery of America, or ever the steam-engine and the magnetic telegraph had been pressed into the service of mankind, one might have expected a machine for sewing. Weaving has been for ages a well-known art, and is at least as ancient as the time of Homer, while sewing till a very recent period has been exclusively performed by hand labour. A century ago nothing was known of the sewing machine in any form, and hardly thirty years have passed since the first machine which would really sew well was constructed. In fact, until Elias Howe in 1844 invented the lock stitch made by a shuttle, embroidery was the object and end of nearly every attempt at sewing by machinery. Every great invention has its growth, and the sewing machine is the result of the thoughtful labours of many minds, but its usefulness dates only from the invention of Elias Howe.

The invention of Charles F. Weisenthal of a double-pointed needle for hand embroidery, and patented in June, 1755, appears to have been the first step towards the modern sewing machine. The needle was "to be used by holding it with the fingers in the middle, so as not to require turning." Thus a desire to cheapen expensive embroidery—to degrade one of the fine arts—led to a decided improvement in one of the most useful industrial arts.

The Phrygians are considered the inventors of the art of embroidery; they carried it to great perfection, and the *vestes Phrygioniæ* were in great favour even among the distant nations of Greece and Rome. The Grecian women were specially skilful in this handiwork, and some of their best efforts were scarcely inferior in appearance to the finest paintings. They deemed it worthy to be classed as a "divine art," and Minerva was in their opinion the inventor of it. Could they ever have thought of a machine to hasten forward their elaborate and artistic needlework?

There are some early English patents for sewing machines. In July, 1790, Thomas Saint was granted a patent for "an entire new method of making and compleating shoes, boots, spatterdashes, clogs, and other articles by means of tools or machines," and among the drawings attached to the specification is one of a machine for "stitching, quilting, or sewing." In this machine there was a vertical awl parallel to the needle, and after the hole had been made by the awl in the material the thread, laid over the hole by a spindle fitted with projections, was pushed through by the pointless needle having a fork or notch at the end. The needle, rising, left a loop which was

caught by a reciprocating hook beneath, which held it until a second stitch was made through the loop, and thus the machine made the single-thread chain stitch. It may have worked well, but it was not in great favour, and gradually fell into disuse.

A French patent, dated February 14, 1804, was taken out by Messrs. Stone and Henderson, "for a new mechanical principle intended to replace hand-work in joining the edges of pieces of all descriptions of flexible matters, and especially applicable to the making of wearing apparel." A common needle was used by this machine, and drawn through the material by two pairs of pincers, placed one above and one below the fabric. The needle was reversed at every stitch, and the thread drawn as it were by two automatic hands. There was little contrivance in this machine, far less than in that of Thomas Saint.

The May following John Duncan's machine appeared, which worked with a large number of barbed hooks, or needles, and was intended for embroidering. It made the chain stitch upon a single thickness of cloth, and with some alterations might have been made to sew.

Twenty-five years later, in 1829, Henry Bock patented an embroidering machine using a large number of needles, each double-pointed, with an eye in the centre. These were passed through the fabric by means of nippers, as in the machine of Stone and Henderson, and were similar to the needle patented by Weisenthal. Josué Heilmann improved this machine, and to a great extent appropriated the honour of it.

A poor tailor of St. Etienne, France, named Barthélemy Thimonnier, invented a wooden crochet sewing machine, and patented it in 1830, and having established the firm of "Ferrand, Thimonnier, Germain, Petit et Cie.," in 1841, through the influence of a government engineer named Beaunier, who saw the merit of the invention, a factory was opened in the Rue de Sèvres, Paris, and eighty of the wooden machines were employed in making army clothing by contract. All promised well, until a mob of angry workmen, filled with rage and jealousy, attacked the establishment, destroyed the machines, and compelled the unfortunate tailor to take to flight. His supporter, M. Beaunier, dying soon after, the great company fell to pieces. Thimonnier returned to Paris, but met with no success, and was actually compelled to earn a living by showing his machine as he trudged back to his home at St. Etienne.

In 1848 he had improved his machine, making it of metal instead of wood, and through the assistance of M. Magnin, of Villefranche, he secured a patent in England, which was finally sold to a Manchester company; but, like all novelties in this country, the machine attracted little attention. Another workshop, set up in Paris in 1848, was destroyed in the Revolution of that year. A machine sent to the London Exhibition of 1851 arrived too late to be noticed in the catalogue, and was most entirely overlooked. His bitter fortune never forsook him, and, after a long struggle against adverse fate, he died in poverty in 1857.

Thimonnier's machine used a hooked needle; the thread was below the cloth, and the hook of the needle being thrust through the fabric caught the thread, and brought to the upper side a loop. Retaining this loop, the needle passed through the cloth again for another loop, and the second loop was drawn through the fabric and the first loop, thus making a chain stitch. It is stated that this machine would sew two hundred stitches per minute; and, if the poor tailor of St. Etienne had not been strangely unfortunate, he would have gained the reward he merited for his clever invention.

Edward Newton and Thomas Archbold in 1841 patented machinery for producing ornamental stitching on the backs of gloves. Six rows of stitches were formed by six needles, each having an eye near the point. This was an inverted chain-stitch machine, as the needles worked from underneath the material.

One of the earliest machines patented in America was that of John Greenough in 1842. It was intended for heavy leather work, and was similar to Heilmann's above described.

Leonard Bostwick's machine had an American origin. In this the needle was stationary, and the cloth, after being crimped by passing between toothed wheels and pinions, was pressed upon a horizontal needle. This formed a running stitch, and was used in bleach and dye works for loose tacking, and later, at Nottingham, for joining lace edgings to lace fabrics.

We have the first mention of the lock stitch in the patent of John Fisher and James Gibbons, granted in December, 1844. It is for "machinery for sewing thread, yarn, gimp, cord, or fabrics in pattern on the surface of fabrics." A shuttle, carrying a thread, gimp, or cord, is used on the upper side of the fabric to be ornamented. "A reciprocating motion is imparted to the shuttle, so that at each ascent of the needle it will pass between the thread and the bent part of the needle, leaving its own thread, which is sewed or fastened down by the thread of the needle on the latter descending. When the needle again rises the shuttle will pass between the thread and the needle in the opposite direction, leaving its own thread as before, and so on till the pattern is completed. If desired, a second fabric may be placed on the fabric to be ornamented; and, when sewed together, the former may be cut away between the figures or patterns." They also patented, at the same time, an embroidering machine, which formed the double-loop chain stitch. Two threads were caused to loop together, "one thread passing through the fabric, and the other looping therewith on the surface without passing through the fabric." Two needles were employed in this machine, a curved one beneath and a straight one above. The point of the curved needle ascended through the fabric, and then the point of the straight needle was thrust between the curved needle and its thread, while the curved needle descending left upon the upper needle a loop. The fabric being moved on, the curved needle ascended again, while the upper needle passed its thread around the curved needle and then retired through the loop of the lower thread.

John Fisher, of Nottingham, the inventor of these embroidering machines, was then a young man only nineteen years of age. His shuttle machine was subsequently modified into a sewing machine; but at the time of the invention there was not the slightest idea in the minds of the patentees that a sewing machine had been invented, and they have acknowledged since that it was not their intention at that time to construct one.

It is generally conceded that the honour of inventing the first practical sewing machine belongs to Elias Howe, Jun., an American, who was born at Spencer, Massachusetts, in 1819. His father was a farmer and small mill owner, and until the age of sixteen the youth remained at home, assisting his father and receiving such an education as could be obtained in the common schools of the State. He inherited a lameness which unfitted him for much hard labour, and in the year 1835 he obtained the consent of his parents to become a pupil in a large workshop where cotton machinery was made, in the busy town of Lowell. The financial embarrassments of 1837 shut the Lowell Mills, and young Howe was thrown out of employment. He proceeded to Cambridge, near Boston, where he found work upon some new machinery for hemp carding, in a large workshop where his cousin, N. P. Banks, since well known in American political and military affairs, was also employed.

A few months later he found a place in the shop of Ari Davis, a philosophical and mathematical instrument maker. This Davis was an eccentric genius, but a good mechanic, and when consulted by inventors, as he was frequently, he would sometimes suggest important improvements in their machines. The story is told that in the year 1839 a poor inventor and a rich man came to his shop with a knitting machine which would not knit, and while Davis and his workmen were examining it Davis exclaimed, "Why do you bother yourselves about a knitting machine? Why not make a sewing machine?"

"I wish I could," said the rich man; "but it can't be done."

"I can do it; I can make a sewing machine," said Davis.

"Well, if you can," said he, "I will ensure you an independent fortune."

These words were uttered thoughtlessly by Davis, but the conversation made a deep impression upon young Howe, who was present, and from that time the desire to make a sewing machine was the dream of his life. He made no immediate effort, however, to attain his wish. He continued a journeyman "machinist," and married when 21 years of age, and not until the additional labours imposed upon him by the wants of an increasing family urged to greater effort did he begin his experiments. He first attempted to make a machine with the double-pointed needle, but, failing in that, he at last hit upon the idea of a needle threaded at the point, and in October, 1844, satisfied himself by a rough model that he could make a sewing stitch, by using two threads and a shuttle. He was at this time living in poverty in a garret. He had given up his employment as a journeyman, and he could scarcely provide his family with bread.

His devotion to his great idea had drawn him away from other labour which would have relieved his wants. His friends thought him visionary, and now, with his invention perfect in his own mind, he was in straits to make any use of it. It happened that an old schoolmate, George Fisher, had inherited a little property, and he was induced to embark some of it in this invention of his friend Howe. An arrangement was made by which Fisher agreed to receive Howe and his family into his house and provide board for them, and also advance him 500 dollars for tools and materials for perfecting his invention. Howe, for, this agreed to surrender half the value of his patent to Fisher, provided the invention proved of any value.

In December, 1844, Howe took up his abode under the roof of his friend, and during the winter was actively engaged in per-

fecting his machine. In April he sewed his first perfect seam, and in July he sewed by his machine all the seams of two suits of clothes, one for his friend and one for himself, which were substantial proofs of the value of his invention. This machine, of which we give an illustration, is capable of sewing 300 stitches per minute, and embodies the principal ideas of all sewing machines hitherto invented.

But even in America, where the people are usually quick to adopt an improvement, the sewing machine at first made little progress. Its cost was too great, 250 dollars or £50 was too much for many people to pay for such a machine, and its actual cost to the maker was this, or more. The tailors would not or could not buy it, and it seemed to be only a toy, after all, to amuse the people. It was patented, however, Sept. 10, 1846. Fisher had now advanced 2,000 dollars, and no prospect appeared of any return for his money.

Mr. Howe now determined to send his invention to England, and in October, 1846, his brother A. B. Howe took over one of the machines to London, which was finally sold to Mr. William Thomas of Cheapside for £250 sterling, with the right to use in his own business (that of a corset and stay-maker) as many more as he wished. It was verbally agreed that Thomas should patent the invention in England, and if the machine came into use he was to pay Howe £3 for every one sold. He also agreed to employ the inventor at a salary of £3 per week in adapting his machine to the work of stay-making. Mr. Howe accepted this offer and sailed for England February 5, 1847, where his wife and three children soon joined him. Mr. Thomas had meantime taken out the patent dated December 1, 1846. In the specification, he stated that the principal feature was the combination of a vibrating needle with a shuttle, but afterwards, July 29, 1858, he filed a disclaimer, by which he yielded the "*general* claim of the application of a shuttle in combination with a needle," &c., for Fisher and Gibbons had patented this combination in 1844. In the Howe original machine the needle had the eye near its point, and was grooved to receive the thread, and thus to allow its entering the fabric more easily. The feed apparatus of this machine was faulty, and has been entirely dispensed with in all sewing machines. The cloth to be sewn was attached to the steel band or plate by the pins upon its edge, and it was carried along by the gearing of a small pinion into holes in this band. The work was held in a vertical position against the side of the shuttle race.

Mr. Howe had little of the success he had hoped for in England. On the contrary, he became very poor, and, although living with the greatest economy, he was hardly able to support his family. He therefore resolved to send his wife and children home to America. He had left Mr. Thomas, and now with a few tools was engaged in making his fourth machine. His first one he still had, the second was in the United States Patent Office, and the third he had sold to Mr. Thomas. He was so poor when his wife, in very delicate health, left him to return home, that he was obliged to pawn some of his clothing to pay for the cab which conveyed her and the children to the ship. His machine, after three or four months' work, was finished, and, although worth £50, he could get no offer for it. At last he sold it to a working man for £5. The man gave him his note, for which Howe realized £4 in cash.

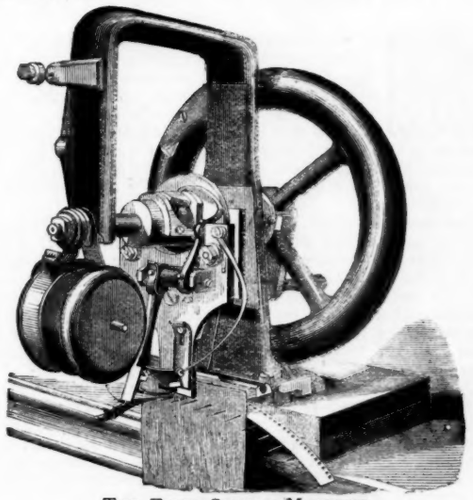
His first machine and his letters patent yet remained to him. These he pawned for £20 and took passage for New York, where he arrived in April, 1849, almost without a penny. Obtaining work at once, enough to supply his immediate wants, he was enabled, by the assistance of his friends, to visit his wife, who lay dying of consumption at Cambridge, Mass. After her death, in proof that misfortunes never come singly, the ship that was bringing over his household effects went ashore, a total wreck, off Cape Cod.

He found that the sewing machine had gained some notoriety during his two years' absence in England, and that already machines were offered for sale constructed on the same general principles as his own. Although very poor, he determined to assert and maintain his rights against all these infringements of his patent.

He first recovered his original machine and letters patent that were in pawn in this country, and then attempted negotiations with the infringers, offering them licences. They all except one were disposed to make terms, but this one prepared to fight it out, and instigated the others to resist. It was alleged that another American inventor named Walter Hunt had, in 1834, constructed a machine embodying some of the features of Howe's machine, and that he had invented the eye-pointed needle and made the lock stitch. Hunt was an ingenious man, and full of ideas which he never carried out to perfection. It was said that he was too poor to develope his invention, and therefore had recourse to a capitalist, one Arrowsmith, who failed soon after the partnership was formed, and neglected for two years to patent the machine. Hunt, to a certain extent appreciating his invention, broke up or hid away his machines, and kept his secret to himself.

When Howe obtained his patent, Isaac M. Singer, who had heard of Hunt's invention, requested him to reconstruct his machine. He did so, but was only partially successful. It was purchased of Hunt, and Mr. Singer doubtless thought there were substantial grounds for resisting Mr. Howe's claims.

At this crisis Mr. Howe found a friend in Mr. G. W. Bliss, who agreed to buy Mr. Fisher's share of the patent and advance money for legal proceedings, provided he was secured against loss by a mortgage on the farm of Mr. Howe's father. The father consented, and after much litigation it was decided in one court after another that Mr. Howe's patent was valid. Judge Sprague, of Mass., in the United States Circuit Court in 1854, said, "There is no evidence in this case that leaves a shadow of doubt that for all the benefit conferred upon the public by the introduction of a sewing machine the public are indebted to Mr. Howe." Appeals were made to the highest tribunal, but the decisions in his favour were not reversed. There was no evidence to prove that Howe had ever heard of Hunt's invention, and it was certain that Hunt, even if he had made a serviceable machine, had made no effort to bring his invention into public notice. Even after seeing the Howe machine work, Hunt was unable to make his own model do anything, while the case before the courts was delayed for months, to allow him the most ample time.



THE FIRST SEWING MACHINE.

The United States Commissioner of Patents decided that Hunt was not entitled to a patent, having sold his invention to Arrowsmith, who had allowed two years to elapse without applying for one.

The rights of Mr. Howe were completely vindicated. Messrs. Singer and Co. finally took licences under Howe's patent, and gave up the contest, and other manufacturers followed. In Salamon's "History of the Sewing Machine" it is stated, that up to September, 1860, Mr. Howe issued 130,000 licences, which gave him a net return of $441,132. He acquired the sole right to his American patent, October, 1855, and in September, 1860, obtained a renewal of it for seven years.

Mr. Howe received from the Emperor Napoleon the decoration of the Cross of the Legion of Honour a short time before his death, which occurred on the 3rd of October, 1867.

It is no more than just to say that the sewing machine owes much of its value to improvements in the feeding mechanism brought out by Mr. J. H. Johnson, Mr. Allen B. Wilson, and others.

The wheel feed is useful in many kinds of work, and is the invention of I. M. Singer. The "four-motion feed" invented by Mr. Johnson, consists of a serrated plate which works in an opening of the table, and brings the work forward under the needle. It first rises, its roughened surface comes in contact with the cloth, it moves horizontally the length of a stitch, then it detaches itself from the cloth by the action of the cams, sinking by the next motion below the plane of the table, and returning to its original position. Thus it moves the cloth on regularly. In the Thomas feed motion the serrated plate acts upon the upper surface of the cloth.

We cannot, within the limits of this article, describe the numerous machines that are now in the market. Many of them are well made, and cannot disappoint the purchaser; others are cheaply and poorly made, and soon become worthless.

Very many improvements have been made in the Howe machine, and it claims a marked superiority for the excellence and beauty of its stitch. The shuttle moves only the distance necessary to form the stitch, and the appliances for the tension of both upper and lower threads are as near perfect as any in use. It does not sew quite as rapidly as some other well-known machines, but it can perform heavy or light work equally well. The genuine Elias Howe machines are all marked with a medallion portrait of the inventor.

In 1874 the Howe Machine Company, Limited, erected large manufactories at Glasgow, where more than 650 persons are employed in supplying the increasing European demand.

The beautiful machinery in use in the American factories at Bridgeport has been duplicated, and 1,500 finished machines are made per week.

THE "DIRECT PROCESS" IN IRON MANUFACTURE.[1]

By Thomas S. Blair, Pittsburg, Pa.

I FEEL a certain sense of responsibility in bringing before you the subject of the direct process in iron manufacture. I am aware that, in such a body as I have the honour of addressing, there are few who are not already so well informed upon its past history that it would be a weariness to them to listen to anything else than an account of practical success. Yet to claim that success involves so much, that, if I do not make good my claim, I deservedly expose myself to severe criticism.

The whole literature of the art, so far as it relates to the direct process, is, up to this time, but a history of failure. It is safe to say that more money, time, and talent have been fruitlessly spent in the pursuit of this object than in all the other unsuccessful efforts in the whole line of iron metallurgy. A distinguished authority in patent law has remarked that "the invention records of the United States and of foreign countries are filled with the waifs and abandoned relics of these abortive struggles."

Dr. Percy, whose great work may be taken as an epitome of all that was worth mention, whether useful or curious in pig-iron metallurgy, up to the date of its publication (1864), after giving elaborate accounts of various attempts at the direct process, condenses his own opinion of all that had been then effected, into a brief but summary comment upon a pamphlet of one of the sanguine inventors who had said, "It is evident that the present mode of working iron ores, whether rich or poor, is not the most rational or economic one, although almost the only one in general use. They convert iron already malleable into cast iron, to be reconverted, at much labour and cost, into malleable iron again."

To this Dr. Percy rejoins: "These questions are extremely obvious. They have been repeatedly proposed before, but never yet satisfactorily answered." Elsewhere he speaks of Chenot (who came so near success that the jury of the French Exposition of 1855 thought he had attained it, awarding to him one of the great gold medals; and Le Play pronounced his invention "The greatest metallurgical discovery of the age") as "poor Chenot," and ridicules the claims set up for him.

Gruner in his "Steel and its manufacture," 1867, translated by Lenox Smith, 1872, says, "Several metallurgists have thought that, instead of smelting ores in a blast furnace, it would be better to simply reduce them to the condition of soft or carburized sponge. They hoped to obtain purer products and consume less fuel by operating at a lower temperature. They were completely deceived. When the sponges are made, instead of cast iron we have blooms of less purity, since they contain, besides the usual cinder, the earthy substances in the ore. And, if the sponges are melted in crucibles instead of forging them directly in the form of blooms, we shall have a homogeneous product, but it will be iron or crude steel of inferior quality, unless the iron sponge undergoes fining like pig metal. In the direct methods, whose object is the abolition of blast furnaces, the addition of carbon mixed with the ore cannot be avoided; and it is this which destroys all profit in the processes invented by Chenot in France, Renton in America, Gurlt in Germany," &c.

Bauerman, who comes later than Percy (1868), gives but slight attention to the direct process. Speaking of the various processes for the direct production of wrought iron from the ore, he says: "As these methods are only applicable to the treatment of easily reducible ores and are essentially slow in work, giving only a small production from a plant of considerable extent as compared with the open fire (Catalan forge), they have not as yet been found to possess sufficient advantages to be generally adopted on a large scale."

Crooks and Rohrig's work (1869), adapted from Professor Kerl's "Metallurgy" gives small encouragement. In the volume on iron they say, in their definition of wrought iron, "It is usually produced by the conversion of pig iron, and in rare cases is obtained direct from the ore." And again, under the caption, "Methods for Making Wrought Iron Direct from the Ore:" "At present this process is seldom used, on account of its numerous disadvantages. It requires pure, rich, and easily fusible ores, and is performed in interrupted operations; much iron is scorified, the consumption of fuel is very large; and lastly the product is seldom uniform, and is mixed with slag, which can only be removed by repeated welding." After describing the Catalan forge, &c., they proceed as follows: "Gersdorff roasts sparry iron ore in reverberatory furnaces, and heats the roasted ore, together with coal, in crucibles. Clay heats ore and coal in a retort, and treats the reduced iron in a puddling furnace. Renton reduces the iron ores in vertical, slightly heated tubes, by means of carbonic oxide gas, and forms the reduced iron into balls in a puddling furnace. Chenot submits the ores to a reducing roasting, to transform them into magnetic oxide, which he finally crushes, and, by means of an electro-magnetic apparatus, extracts the magnetic components; he then reduces the ore with carbonic oxide gas, grinds the resulting spongy iron, mixes it with soda, presses into cylindrical shape, and at a suitable temperature draws it out into bars. Roger heats the iron, together with coal, in a rotating cylinder, and forms the balls in a puddling furnace. None of these methods seem to have met with any practical success."

In their volume on steel they say, under the heading "Steel Direct from the Ore," "Gurlt proposes to treat rich, pure iron ore in cupola furnaces by means of carbonizing and reducing gases, and to melt the resulting product in a gas reverberatory furnace, but this method has not proved successful when carried out on a large scale. By Chenot's method, rich, pure ores are reduced in cupola furnaces by interstratified layers of charcoal; the resulting spongy products, containing various amounts of carbon, are sorted and ground in mills, and the mass is pressed into cylinders and melted in crucibles, sometimes together with coal and a purifying and scorifying flux of manganese. This method has been tried in Belgium without economical success, and it does not permit the production of cast steel containing a fixed proportion of carbon.

The newest and most promising way of producing steel direct from the ore is Mr. Siemens' method with the regenerative gas furnace. This is the method described by Mr. Siemens before the Chemical Society of Great Britain, May 7th, 1868. The main feature is the vertical hoppers in which the ore was to be reduced, and the product dropped thence into the bath of an open-hearth furnace. (Further on we shall see that Mr. Siemens states that it has been abandoned.) Neither Kohn nor Fairbairn appear to have thought the subject worthy of serious notice.

Under the date of February 27th, 1869, we have the record of the opinion of a metallurgical chemist, known to you all as an eminent authority. I allude to Mr. Geo. J. Snelus. I quote from an English patent granted to him, of the date just mentioned: "In the ordinary process of making iron, the ore is reduced under such conditions that it immediately takes up carbon and is converted into cast iron. Several attempts have been made to produce wrought iron direct from the ore; but, either owing to the process not being continuous, or its requiring too much time and fuel, or its inapplicability to the treatment of fine ore, and *the incomplete reduction* of the ore, none of these attempts have yet been successful in such a degree as to afford the means of making iron or steel so economically as can be done by first forming pig iron in the blast furnace."

On this side of the Atlantic, with one notable exception, the direct process received little attention in the literature of iron metallurgy. The exception I refer to is the report of Dr. T. Sterry Hunt, addressed to Sir W. Logan, Director of the Geological Survey of Canada, 1869. In this report the author says, "In accordance with the well-known fact that the reduction of oxide of iron takes place at a temperature very much below that required for subsequent carburization and fusion, it has been shown that the charge of ore in the blast furnace is converted to

[1] "Transactions of American Institute of Mining Engineers."

the metallic state some time before it descends to the zone in which melting takes place. It forms, when reduced, a spongy mass, readily oxidized, which, by proper management, can be compressed and made to yield malleable iron, or by appropriate modes of treatment may be converted into steel. This fact has been the starting-point of a great number of plans designed to obtain malleable iron and steel without the production of cast iron and the employment of the processes of puddling and cementation. This, it is true, is attained in the Catalan and blooming forges, *but the attention of many inventors has been, and still is, directed to the discovery* of simpler, or at least more economical, methods of obtaining similar results."

Dr. Hunt then proceeds to sketch all the direct process, in this country and abroad, worthy of mention, up to the date at which he wrote, pointing out in each case the difficulty or drawback developed in practical working. It is a brief but comprehensive history of the subject, and tells the same story in every case,—failure to reach any large results.

The British Iron and Steel Institute may certainly be taken as embodying the latest and most advanced ideas in everything that relates to iron metallurgy. At its meeting in London, March 19th, 1872, the discussion which arose respecting the Danks puddling furnace, brought out incidentally an expression of opinion on the direct process from some of its most eminent members. Mr. Edward Riley said: "As regarded making wrought iron direct from the ore, he believed there was certainly very little hope of that being carried out practically or profitably. He thought no one could conceive any method more simple than the present process of throwing materials into the blast furnace for the purpose of reducing them, and he was sure that all improvements in iron should commence with the pig iron. They could make it in any quantity, and they ought to start there. He could not conceive of any other process of making iron cheaper."

Mr. Isaac Lowthian Bell "thought that a certain amount of disrespect had been shown," in a previous part of the discussion, "with regard to the blast furnace, in speaking of it as a round-about way of doing the work which was performed by it. There was no doubt that they combined the iron with the carbon or silicon in the smelting process, which had subsequently to be dispersed; but they must remember that the blast furnace, at the same time, got rid of earthy impurities generally found associated with iron ores. He, therefore, quite agreed with Mr. Riley that, although it might be a round-about way in the first instance, they could not conceive any means so simple for getting rid of a large amount of extraneous matter as blast furnaces."

These views appear to have been acquiesced in by the members generally. At their meeting in April, 1873, Dr. C. W. Siemens read a paper, which, from the distinguished position of its author and the character of its reception by his associates, may reasonably be supposed to represent the condition at that date of the art of iron-making in Great Britain, so far as relates to the direct process. After describing the various attempts made by him to bring the direct process into practice, and explaining the reasons which induced him to abandon them, one after the other, he uses these words: "These experiments convinced me that the successful application of reduced ores could not be accomplished through their conversion into spongy metal, and fully explained to me the want of success which has attended the previous efforts of Clay, Chenot, Yates, and others, to produce iron direct from the ore." He then describes a new method and apparatus, wherein he begins by abandoning one of the cardinal features of a truly direct process, a feature pointed out by Dr. Hunt in the extract I have already quoted, viz., that the reduction of the oxide of iron can be obtained at a heat much below that required for its consequent combustion and fusion. Dr. Siemens, despairing of realizing this feature, begins, in his new process, by fusing the oxide.

Such, I think, may be called a fair statement of the literature of the subject up to the present time. Furthermore, its uniform and consistent record of failure is borne out by the facts. It would have been, for example, impossible for a metallurgist, so intelligent and deservedly esteemed as Gruner is, to commit himself to the statements I have quoted if, at the time he made them, there had been in existence, as an article of manufacture on a large scale, a *true* iron sponge. He speaks of the "earthy substances" as causing "impurity," and says that the sponge when melted will, it is true, give a homogeneous product, but of inferior quality, "unless the iron sponge undergoes fining like pig metal." Had he been acquainted with iron sponge, whose only "impurities" (in quantities sufficient to be objectionable) were silica and alumina, could he have fallen into the error of stating that the impurities could not be removed by the state of fusion, but only "when the iron sponge undergoes fining like pig metal?"

So with his statement that the necessity of adding carbon in the direct process "destroys all profit" in it. Had he been acquainted, I say, with true iron sponge, and familiar with its manufacture into iron and steel, he would have recognized the fact that in iron sponge we have the least possible affinity between the earthy substances and the metal. And he undoubtedly would have been thus informed had such practice been known in the art.

But, setting aside all these, I come down to the present hour and present place, and our own country, and I ask you here present, who are familiar with all the industries of the nation, whether you have knowledge of any direct process for the production alike of iron and steel, now carried on upon a working scale, as a successful rival of the ordinary indirect methods?

When one considers that the immense results which must flow from the successful achievement of the direct process are understood by all scientific men, and have been by them so understood for years past, it seems like presumption to attempt to carry off a prize which all have hitherto either despaired of, or, seeking, have failed to win. It seems so plain, so easy, yet has still remained, as it were, just out of reach. There must be, one would say, some hidden but insuperable difficulty, else the problem had long since been solved. Consider for a moment how inviting a field it is. Nature provides us with the metal we want, chemically combined with oxygen, and mechanically mingled with other substances. Let us withdraw this oxygen from the iron only, leaving the rest as compounds, it alone being elementary. Now let us melt the product, so that the iron shall, simply by difference of gravity, be separated from the dross, and then poured into proper moulds. Here we have but two steps, each of great apparent simplicity—first, reduction; second, fusion. Such is the ideal, which, by contrast, makes the old system appear so crude, unscientific, and round-about, that the term "direct," applied to the new method, sounds like the promise of a great and beneficent revolution.

We know that carbon at a certain heat will dissociate the iron and the oxygen, yet leave the other mineral matter of the ore unreduced, giving metallic iron — wrought iron — as the result. We know further, that we have at command furnaces in which the product can be melted down in a bath of cast iron, and so treated that it shall result in ingots of any desired degree of carburation. We know that, if the reduction of the ore can be effected, the elements of cost in fuel, labour, &c., will make the product cheaper than pig iron, and also that the melting process is less costly than puddling, whereas its product is of far greater value. Why is it, then, that while the whole iron industry of the world is struggling by small economies to realize a return upon its capital, this most plain, most prominent of all economies remains unpractised?

There has been a link missing—without it, all is nought. There has been no thorough, uniform, economical process of reduction. The missing link is true iron sponge. It is that which I come here to exhibit to-day; to tell you how it is obtained, and to show you that, by the means I shall describe, it is within the reach of all. Let me be your guide while we travel together, in thought, from the point at which I started to the final point of success. It shall not be the path I travelled. This time we will take the smoothest and shortest way.

We are in a chemical laboratory. We take a small porcelain tube and fill it with a mixture of pulverized peroxide of iron and charcoal; next we seal the ends of the tube hermetically, then expose it to heat by immersing it in a bath of brightly red-hot sand for a certain time (varying with the character of the ore), then take it out, cool it, and, after cooling, break it open, and pour out the contents. Carefully separating and testing them, we find that we have obtained particles of metallic iron. Now what condition did we observe to get this result?

First. There was contact of the iron oxide with carbon.

Second. There was isolation from the free oxygen of the atmosphere.

Third. There was the heat of bright redness.

Fourth. There was a certain duration of time.

Fifth. There was continued isolation from the air until cold.

Hence we have established the fact that, if a peroxide of iron be brought into contact with a sufficient quantity of carbon, with perfect isolation from the atmosphere while exposed for a sufficient length of time to a sufficient heat, and then cooled down to a sufficient degree while still isolated from the air, the oxygen and the iron will be dissociated, the oxygen passing off in a gaseous form, leaving the iron behind. Now, chemistry supplies all the data for filling up with absolute figures the blanks in this statement, and we have in consequence a formula by which, if strictly carried out, we can achieve the first of our two great steps in the direct process—we can gain the metallic iron directly from the ore. Hence the chemistry of the operation is clear, and it becomes simply an engineering question

how to meet all the necessary conditions, so as to conduct it on the large scale.

First, we investigate previous attempts, striving to detect what is defective, recognizing what is correct, and supplying what yet is wanting. Proceeding in our course of elimination, we first reject all those methods in which it is sought to yoke the production of the iron sponge directly with a method of treating it; those, for example, which are meant to reduce the ore in one chamber and pass it as fast as reduced (or supposed to be reduced) into another chamber for after-treatment—welding, melting, etc. The operations cannot be made synchronous. One or the other must be disarranged in order to accommodate its fellow.

Confining ourselves, therefore, to the simple question of reduction, we finally give the preference, among the multitude of contrivances and appliances, to the vertical chamber, to be filled at top and drawn at bottom, and working continuously. But in all these we discover one fatal defect; there is no adequate provision for the isolation of the material, either while under treatment, or cooling, or both.

We experiment ourselves, and despair of obtaining the desired result by any arrangement of valves, or slides, or the like contrivances. The dilemma is this: we want an apparatus that, as I have said, shall work continuously, and on a scale of considerable magnitude, taking in and discharging material at short intervals, yet always closed to the entrance of free oxygen. Or, otherwise stated, we must have a chamber so open at top and bottom that we can dump in a cartload of crude material above and draw out a cartload of finished product below, yet be all the time hermetically sealed against admission of air. Now this chamber—assuming that we have settled upon the plan of filling it with ore and solid carbonaceous matter, and heating them through its walls—must be surrounded by heat for a certain distance down, and by a cooling medium below that, because we intend to reduce and then cool down. Well, we find that our difficulty as regards the keeping out of air at top takes care of itself. The solid oxygen and solid carbon, down in the zone of reduction, are combining as carbonic oxide, and, by virtue of their great expansion, forcing their way upward and out so that they arrest every particle of free oxygen before it can penetrate downward. As to the bottom, however, we have not this resource, and must find another. We get it by giving to our chamber such proportions that there shall always be above the place of egress a column of material, so cool itself as to be proof against the influence of oxygen, and of such a height as to form a packing, which shall seal up all that material above it which has not yet reached the safe degree of cooling.

By this device, which surely is as simple as anything in metallurgical engineering, our dilemma is answered. We are now operating, in regular practice, at Glenwood, cylinders of 3 ft. internal diameter, and 40 ft. in height, which are open tubes, so far as relates to the taking in and discharging of their contents, but, as relates to access of air in their working zones, are sealed retorts; the seal above being the ingoing material itself and the gases percolating upward through it; and the seal below, the material which, by cooling, has become indifferent to exposure. For the first time, then, in the history of attempts at the direct process, we have at our command complete isolation, yet continuous working.

Let us next take up the question of imparting and maintaining the necessary heat. Here at once another difficulty confronts us. We must work upon a scale of considerable magnitude, and our reducing chambers, must, therefore, be of considerable area. But their contents are very poor conductors of heat, and a little experience will convince us of the impracticability of getting an evenly distributed temperature by conduction from the outside through a mass of, say, 3 ft. diameter. Now, we must have uniformity of temperature to get uniformity of result, and the system we have adopted obliges us to impart the heat by conduction. We could conduct it, we will say, through 3 in. of the materials, in time enough to answer all practical purposes, but not through 3 ft.

Let us see, therefore, if we cannot bring every particle of the material within 3 in. of a sufficiently heated surface. Thus stated, you will probably guess at the solution of the problem. It is this: When charging your material into your cylinder, cause it to pass between heated surfaces in streams whose greatest distance, in any part, from a sufficiently heated surface, shall not exceed your limit of 3 in.

This, you will readily perceive, may be done in many ways. Let me describe to you one of the arrangements which I employ. It accomplishes very economically the purpose just explained, and performs another function which I will refer to directly.

In the top or mouth of the reducing cylinder I suspend an inner cylinder or thimble of cast iron, with walls, say 1 in. thick, and having an outside diameter of 28 in.

Now, the reducing cylinder has an inside diameter of 36 in.; hence there is left an open space or annulus between the two of 4 in. across.

I charge my materials into this annulus only, so that all have to pass downward through it, and none can be more distant than 2 in. from the heated surface either of the cylinder or of the thimble. I make the thimble long enough—say 6 ft.—to insure that all the materials shall have acquired the temperature desired before they descend below the annulus.

This "initial heating," as I call it, establishes one of the primary conditions with which we started out—the imparting of the necessary degree of heat—the only duty required of that portion of the heating chamber which surrounds the cylinders below the level of the bottom of the thimble being to prevent the escape of the heat thus imparted. You will observe that this device completely meets the whole difficulty as to the conduction of the heat, so that—whatever the diameter of the reducing cylinder—it is only a question of what diameter and length you will give the thimble, in order to impart your materials the temperature you wish.

We have now got thus far. Our reducing furnace shall consist of one or more cylinders (adopting the cylinder as the preferable form of chamber), which shall be heated externally for a certain distance from the top down, then cooled the rest of the distance downward to the base, excepting the room required at bottom for raising the telescopic sleeve for the discharge of material.

At its top is the thimble for initial heating.

Let us now revert to our original statement of the conditions to be met, and see if we have fulfilled them.

First. We provide the contact of iron ore and carbonaceous matter by mingling them before discharging into our cylinder.

Second. We isolate these materials from free oxygen while in the zone of reduction.

Third. We conduct the required degree of heat through the mass.

Fourth. Our apparatus enables us to hold it under treatment for any length of time desired.

Fifth. We have continued the isolation until the product was too cool to be oxidized on exposure to the air.

Thus we have realized, upon a working scale commensurate with the requirements of the art, the laboratory experiment of the sealed tube, and the manufacture of iron sponge becomes as simple as any of the ordinary operations in the art of iron-making.

From the general principles above laid down, it will be easy to plan a good working reducing furnace; but there are a number of details, both of construction and management, which I think may interest you.

I have already alluded to the thimble arrangement for the "initial heating," as having another recommendation beyond its convenient form. What I referred to is this: When the carbon dissociates the oxygen from the iron, carbonic oxide is formed, and this, rising as I have said, passes outward by way of the interior of the thimble, as furnishing a line of less resistance than the annulus, packed as the latter is with the ingoing materials. As it ascends through the thimble it is met by the air, which, in virtue of its greater weight (being colder), and from the tendency to transfusion in gaseous bodies, descends into the thimble, and a perfect combustion of the carbonic oxide is kept up.

Thus the carbon, which had served as a chemical agent in the reduction of the ore, is made to do duty once more, as a fuel.

Speaking of fuel, I would say that my method of heating the cylinders is to place the portion of them to be heated in a chamber of brick, which is supported on iron pillars; thus leaving the cooling zone accessible below. This chamber is heated by letting into it streams of gas at different levels, with an air inlet adjacent to each inlet of gas. All, of course, are arranged so as to have the gas supply under convenient control. Aside from the economy of gaseous as compared with solid fuel, it is incomparably easier to keep a chamber such as this at a uniform temperature with gas than to heat it by burning coal or wood on grates.

While on this subject of fuel, I may say that I am tired of the ordinary form of gas-producer. It is certainly a clumsy affair.

I hope to have something interesting to say, upon a future occasion, as to a better form throughout. Meantime I would suggest to others, who find the clinkering to be as much of an annoyance as I do, to try—as I shall soon—in the present form of producer, a water-tox all round, as high up as clinkers born, and water-bars like those sometimes used under boilers.

I not only introduce the gas into the heating chamber, but also carry a pipe into and project it downward nearly to the

bottom of the thimble. By this means, whenever the gases developed in the cylinders, as before explained, do not suffice to keep the heat of the interior of the thimble up to the point desired, I turn on other gas enough to make up the deficiency.

Thus I secure perfect control of the heat of the thimble, and make sure that the material in the annulus will always be hot enough to be ready for dropping when a charge is drawn from below. In this way the output of the furnace is limited to but one consideration, to wit, what duration of exposure to a red heat is necessary to perfect the conversion. The amount of fuel required for heating is about one-third of a ton of iron in the sponge turned out. Any description of fuel commonly used in gas-producers will answer. As to the cooling, the reducing cylinders underneath the heating chamber are prolonged simply in wrought iron of ¼ inch thickness, and each is surrounded by a jacket, which is kept full of water continually changed. The wrought-iron cylinder ends about 18 in. above the floor, and a sleeve, working telescope fashion, closes the remainder of the connection when let fully down. By raising the sleeve more or less, as required, the material gushes out underneath, and as it does so the whole column of material in the cylinder descends, leaving a space at the top of the annulus, which is immediately filled up with fresh material.

I do not find that the size of the ore makes any practical difference, whether it is, say, 2 in. through, or any smaller. This fact has been observed in experimental work heretofore, but I have never seen, nor been able to frame for myself, any explanation that is quite satisfactory. I suggest it as an interesting subject for our fellow-members of the chemical profession.

It has been stated in the books that the sesquioxide of iron in the process of reduction first becomes magnetic oxide, then protoxide, then metallic. This appears to be demonstrated by the fact which may often (if not always) be observed in pieces too large to be "done through" (as the workmen phrase it), in the time during which they were under treatment.

If the size of the piece is large, say, 4 in., and the core is still quite raw, but the outside completely reduced, the concentric layer next to the core will be protoxide, the next magnetic oxide, and the next the iron sponge. Not that these layers are distinctly defined, but merge into each other at the points of contact. But if the size is kept within the limit named there is usually no distinction to be observed, and the pieces, if anything near raw at the core, will usually show signs of protoxide on the surface.

I must, however, qualify my remark as to the comparative time required for the reduction of pieces of different sizes. I did not mean to include ore in fine particles. This does appear to be more rapidly reduced than that which is coarser, but as it is cheaper to break the ore only to a moderately small size, and the fine powder is hence an insignificant fraction, I have not observed it closely in this particular.

With respect to the time required for treatment, it varies according to two sets of conditions.

The first is that of chemical composition. The sesquioxides are more easily reduced than the magnetic, and the latter than the protoxides. Hence hasty reasoners, who might argue that, because the sesquioxide had to pass through the stages of magnetic and protoxide before becoming metallic, it must, therefore, be the hardest to reduce, would find themselves in direct opposition to the fact. The explanation, I suppose, is this, where the oxygen most abounds, reduction is easiest to commence, and, once on the move, the operation proceeds rapidly.

The second set of conditions are those of mechanical structure. The massive materials are, as one would naturally suppose, harder to operate upon than those which are loose and open. The brown hematites are capital subjects for the reducing furnace. As soon as they reach a red heat, the water of combination is driven off, leaving an open, sponge-like structure, and, being also sesquioxides, we have both the chemical and mechanical conditions for speedy reduction. The compact hematites, such as the Iron Mountain ore of Missouri, and the red specular of Lake Superior, though sesquioxides, have no combined water, and are of a dense structure. In consequence, they require a much longer treatment. The magnetic oxides, such as those of Lake Champlain and the iron sands of the St. Lawrence, being both very compact, and leaner in oxygen, require a longer time still than the compact hematites; while the protoxides, when in such a shape as, for example, the dense tap cinder from the puddling furnace, are extremely obstinate under treatment.

Among the curiosities of the reduction of iron oxides is the fact that the intensity of action bears but slight relation, within certain limitations, to the degree of heat employed. This is a fact noted by Mr. I. Lowthian Bell in his experiments with the blast furnace. It suffices for our present purposes to state, as relates to it, that there would be no particular acceleration of the process gained by pushing the heat to a degree that involves danger of welding the material together while under treatment.

But I am able to announce to you another very important fact, and one not to be found in the books, namely, that at the temperature of reduction—say a fairly bright red heat, and with carbon alone as the reducing agent—no carbon whatever is taken up by the iron. I think it sufficiently indicates the state of the art of iron sponge making as it has been hitherto, when I tell you that I asked this question direct of one of the most distinguished and most practical of the foreign authors I have already quoted, and the answer was that, to the best of his knowledge, the point had never been settled. Now, if you will consider for a moment the immense importance of this question—the question whether your product is to be wrought iron alone—a product which you can employ as iron or carburize with precision to the temper desired, or whether it is to become an unsettled and uncertain carbide of iron, to be sampled and analyzed, every lot, before using, and from which carbon must be removed if wrought iron is to be made from it; when, I say, you consider the magnitude of this question, and the fact that neither the man of science nor the practical manufacturer had any answer for it, you will agree with me that the art had not yet made much progress.

But, at all events, the question is now set at rest. I have had frequent analyses made of iron sponge, produced from various descriptions of ore, and in no case has combined carbon been found. The iron sponge, sensitive as it is to many chemical reactions, only takes up carbon (when presented unaccompanied by an accelerating agent) as other wrought iron does, to wit: at the recognized heat of cementation, a heat far higher than we need to (or ought to) employ in the reducing furnace.

With respect to the carbonaceous matter used as the reducing agent, I would state that, in regular practice, we have, up to the present time, made use of charcoal. We have tried both coke and anthracite, but merely in an experimental way. We have not been prepared to remove the sulphur from either, and—having so many other things to get into working order—have preferred to run no risks in this particular. Our experiments have been conclusive, however, as to the reducing power of these substances, and we shall, early in the spring, take measures to use coke from washed coal. We have experimented with a Bradford separator, and find that the fine "slack" of the Pittsburg coal can be so freed from sulphur that even if none were driven off in coking, and the whole of it absorbed by the iron in the reducing cylinder, there would not be over 0·08 per cent. in the iron. For the country east of the Alleganies, the anthracite culm should furnish an exceedingly cheap reducing agent. I am informed that there is no difficulty in removing the sulphur by treatment with steam charged with alkaline vapours, and at moderate cost. I have not yet had any practical experience, however, in this matter.

The estimate of quantity required per ton of iron produced is very easily made. For brevity's sake we will consider only the sesquioxydes, as they require the largest ratio of carbon. They carry 70 per cent. of iron to 30 per cent. of oxygen. Now, every 30 parts, by weight, of oxygen take up 22½ parts of carbon, so that we employ 22½ parts of carbon for every 70 parts of iron, or 32·14 parts of carbon to the 100 of iron; in round numbers, one-third ton of carbon to the ton of iron in the sponge. It may occur to you that this is the theoretical quantity, and that in practice it must require more. But such is not the case—at least to any appreciable extent. No carbon is used in the reducing cylinder except what is taken up by the chemical operation referred to above. None of the other oxydes of which the ore is composed are reduced, and there is no free oxygen present to consume any carbon. Whatever excess, beyond the amount absolutely required, we may mix in with the ore, to secure a sufficiency throughout the mass, is regained at the bottom of the cylinder.

I would now ask your attention to the fact that, in my statements respecting reduction, I have hitherto confined myself to the case of reduction by carbon only. You are aware, however, that there are certain substances, such as cyanogen, hydrogen, &c., which, when present with carbon, exert a singular power in accelerating its combination with iron. Some of these substances, as, for example, hydrogen, are also in themselves powerful reducing agents. You will see at once how the employment of these may vary the results. The hydrocarbons, for example, will produce reduction at a lower temperature or with great saving of time, but will yield an irregularly carburized sponge. The field is too large to enter upon here, and must be passed over with this brief notice, to be reverted to, however, for a moment when I come to speak of the second branch of the direct process, viz., fusion.

There is another feature of the reducing operation which has been remarked upon by some accurate observers, such as

Mr. I. Lowthian Bell, but which appears to have been unsuspected by the generality of those who have attempted to make iron sponge. It is this, that the resistance of the oxygen against its dissociation from the iron increases in inverse ratio to the quantity remaining. Thus, to get out 50 per cent. of it, for instance, is a very easy and a very short operation; to get out the next 25 per cent. may perhaps not take much longer additional time than to abstract the first 50 per cent.; but the refractory quality in the oxygen keeps rapidly rising until it becomes practically almost a matter of impossibility to get out the last remnant of it. Ignorance of this simple law has kept many a sanguine inventor pursuing an *ignis fatuus*, and at its door must be laid the corpse of many a once cherished, but now lifeless, "process."

From it arises the talk, sometimes so freely indulged in, about iron sponge as a well-known article, quite at command if wanted.

As a curiosity in this line, let me quote from an English patent of 1870, taken out by a practical manufacturer, a manager of steel works: "The reduction of the ore to the condition of spongy metallic iron is a matter of comparatively little difficulty, and may be effected in various ways," etc.

These so-called iron sponges carrying, say, 10 per cent. of the iron as protoxyde, are not the materials with which to obtain a victory over the old, well-established, indirect process. They will give too poor an account in yield, however used, and they are especially objectionable for open-hearth practice. Dr. Siemens covers the whole ground in a few words, in his American patent of April 11th, 1871: "The metallic oxyde corrodes the banks of the metal bath."

Let us turn now to the second step in the direct process, the fusion of the iron sponge. I will pass by all other methods of treatment and confine myself to this, the most important. The open-hearth gas-furnace enables us to produce a homogeneous product cast into ingots. We will not stop here to discuss the various definitions of "steel" as distinguished from "iron." For present purposes we will adopt the popular conception, and apply the term steel to what a blacksmith would call steel, that is, whatever will "take a temper," and iron shall mean what the blacksmith would call iron, that is, what will stand the same heat and weld the same way as that which he has always called iron, and which will not take a temper.

These ingots of iron or steel (according to the ratio of carbon contained) are produced by melting wrought iron in cast iron. Here, then, is an operation for which the sponge is especially adapted.

It is more fusible than any other form of wrought iron, and its mineral portion will be separated by the act of fusion, without any special treatment whatever.

I had no other idea than to use the "Siemens" regenerative gas-furnace (that being the one invariably employed heretofore in open-hearth practice) until I came to arrange for a licence, when I was informed by the agents in this country of Dr. Siemens, that my licence must contain the stipulation that I could only employ in the furnace such materials as he (Dr. Siemens) would permit me to use; and my iron sponge was not embraced in the list. After repeated efforts I found it impossible to shake his determination that his furnace should not be employed for any other direct process than his own. I was, therefore, obliged to look elsewhere, and, happily, found what I sought in the gas-furnace of Mr. H. Frank, of Pittsburg.

This furnace works on a system of "continuous regeneration," the waste gases passing continuously in one direction outward, and the air and gas supply passing continuously in one direction inward. I regret that the length of this paper compels me to omit a detailed description of this most satisfactory furnace. It gives all the heat that can be used (the endurance of the structure being the limit), and works with the greatest steadiness. All clogging of the regenerators by tar and soot is avoided by the simple expedient of alternating the currents of gas and air so that the air is made to pass through the chamber where the gas had previously been, thus burning out all those deposits, while the gas finds a clear passage in the other chamber where the air had been flowing. It is only necessary to make this alternation between heats, so that, from the time of charging until the cast is made, the only manipulation called for is the adjustment of the inlet-valves for gas and air, and of the damper of the stack.

Our present practice at Glenwood is to take the iron sponge and press it, while cold, into blooms of 6 in. diameter and about 12 to 18 in. in length. A specimen of these is exhibited here. The pressing is performed by hydraulic machinery, and the force exerted is about 30,000 lbs. to the square inch, or about 900,000 on the bloom. Thus prepared, we charge them into an auxiliary heating furnace, where they are brought to a bright-red heat, and then thrown into the bath of the melting furnace. We use no other form of wrought iron whatever. Otherwise there is nothing peculiar in our operations, and everything goes on just as if we were melting ordinary blooms, except that the fusion is much more rapid. We have no difficulty whatever with the lining of the furnace, owing to the small amount of protoxide left in the sponge, there being decidedly less than is usually found in puddle-bar. It is here that the perfection of the reduction tells.

We have operated hitherto with ores so rich—Iron Mountain of Missouri, and Red Specular of Lake Superior—that we have no excess of slag. On the contrary, we generally find it expedient to throw in a little cinder from a previous cast. When using ores which carry so much earthy matter that the slag would be in excess, we shall "bleed" it away, to the extent desired, from a cinder-notch which we have provided in the wall of the furnace.

I propose to do away with pig iron, at first in part, finally altogether. There are two ways of doing this, both of which I shall practise long enough to determine which seems preferable, and hope to have the pleasure, on some future occasion, of reporting the results to you.

In the first method I avail myself of the system of rapid carburization practised in "case-hardening" and in the melting of wrought iron in crucibles, viz., the employment of an accelerating agent, such as cyanogen, along with common carbonaceous material. Mixing one or more of these agents with charcoal dust, and the resultant mixture again with sponge before pressing, I have a bloom which holds the carburizing materials in intimate contact with the particles of iron, and it is a question to be developed by experience what amount of carbon can be imparted to the iron up to the time of its fusion.

In the second method I take up Gurlt's idea of the carburization of sponge by hydrocarbon vapours, and apply it to my reducing furnace in this way:—I have tapped a gas-pipe into one of the cylinders, so as to furnish an inlet by which I can force gas into and among the contents of the cylinder. This inlet is placed just above the cooler, so that the gas will enter when the material is yet hot, but has passed below the zone of reduction. I generate gas from benzine, in an apparatus placed at such a distance from the building as to be safe, and under pressure sufficient to overcome the resistance in the cylinder. I shall thus get the carburizing action without any other extra expenditure of fuel than the small amount required for generating the benzine gas. The apparatus is now just ready to go into operation, and I expect to impart such a quantity of carbon to the sponge as to render it readily fusible without the aid of a bath of cast iron.

I consider it a very desirable step, in the perfecting of the direct process, that we should dispense with cast iron in the open hearth, for two cogent reasons: first, because we have now turned the tables, and wrought iron is cheaper than pig; and, second, because the less pig we use the better the quality of the product. Dr. Siemens, in the paper from which I have already quoted, puts this matter in a very clear light. Speaking of the desirability of a direct process as regards the question of quality, and referring to one of Mr. I. Lowthian Bell's diagrams of a blast furnace, he says:—

"It shows that the reduction of the metallic oxides to spongy iron is accomplished within the first 20 feet in their descent in the furnace, and at a comparatively low temperature. This upper zone is followed by one where the limestone is decomposed and the carbonization of the spongy metal is commenced. Between this second zone and the zone of fusion in the boshes of the furnace, one of great magnitude intervenes, where apparently no other change is effected than an increase of temperature of (the) spongy metal, but where in reality a very powerful reducing action is accomplished of substances which had much better not be joined to the iron. It is well known that almost all the phosphorus contained in the ironstone and the coke is here incorporated with the spongy iron. The silica is reduced to silicon, and, together with arsenic and other bases which may be present, combines with the iron. The final action in the blast furnace only consists in fusing those reduced substances and forming the slags which envelop and protect the fused metal."

On the other hand, as I have already explained, the low temperature at which the reduction of the iron oxide takes place in the direct process gives no opportunity for reduction of the other oxides accompanying it. Hence, though the mechanical union remains, there is no chemical affinity, and as we, in our second step, produce the fusion under conditions which do not allow time for the reduction of the other substances, we get away our iron uncontaminated.

Here, again, I have to regret that time and your endurance do not allow me to do more than refer to some exceptions to this, in the case of sulphur and phosphorus. As to the former, it is perhaps unnecessary for me to explain how the difficulty can be overcome. As to the latter, I will say, speaking from absolute experience, that no difficulty arises where the phosphorus exists

—as in the Lake Champlain ores—in the condition of phosphate of lime. With respect to other phosphorus-bearing ores, I hope to make a special report to you, when I can enter into details which are inadmissible here, and after I have more extended experience. I must also defer anything beyond a mere casual reference to titanium, which gives no trouble in the direct process.

Dismissing these interesting topics, I close my explanatory statements, trusting that nothing further is needed to satisfy you that you have now presented to you a perfectly practical and thoroughly direct process for obtaining the ingot of cast steel or homogeneous iron.

Little need be said as to the value of this product. Open-hearth practice has already established the fact that steel fit for all purposes short of edge tools can be produced (even when using the system of melting wrought into cast iron), and that the homogeneous metal is the type of all perfection in wrought iron. With respect to the results which will follow the introduction of the direct process into the field of iron metallurgy, I do not venture any prediction as to how speedy or how slow may be the revolution. Some time must elapse, during which the old system will regulate the market price, while the new system will (for those employing it) regulate the cost. But, with such data as I will now very briefly call your attention to, it is easy to see that the old system must either be greatly cheapened, or it must, sooner or later, be overgrown by the new.

The direct process demands so much smaller an amount of fuel that the proper plan for realizing the most profitable results in practising it will be to go to the mines, and there produce the sponge at least, in many cases the ingot also. The extreme simplicity of the plant required, and the ease with which the process can be conducted on a small scale, if desirable, also point to the mine as the proper locality for the works, up to, as I say, the sponge always, the ingot often.

Take, now, such a locality, where ore of 50 per cent. metallic iron is worth $4 per ton and charcoal is worth 6 cents per bushel. We have :

2 tons ore at $4	$8·00
40 bushels of charcoal, at 6 cents	2·40
Gas-producing fuel (wood) say	1·00
Wages, say	3·00
1 ton iron in sponge	$14·40

Let us add $5·60 per ton for transportation to a manufacturing centre, making the cost of the sponge, say $20 delivered. Add $2 per ton for cold pressing.

One ton of ingots will cost about as follows:—

¾ ton cold-pressed blooms, $22	$16·50
15 per cent. waste on the same	2·48
¼ ton Bessemer pig, at $45	11·25
7½ per cent. waste on the same	·84
Wages, per ton	5·00
Maintenance of furnace, &c.	2·50
Spiegeleisen, $\frac{1}{10}$th ton, at $70 per ton	3·50
¼ ton fuel for producers, at $5 per ton	3·75
Cost of 2,240 lb. ingots	$45·82

Assuming that we shall be able to substitute carburized sponge for the Bessemer pig, we reduce this to about $38·50.

The figures must be varied to suit every different locality, and, in those where ore is a high-priced commodity and fuel cheap, there will not be as great a difference in favour of the direct process as where those conditions are reversed ; but there will always be enough to give it an advantage that must tell eventually.

Finally, there is one aspect, at least, of this branch of the subject that must be gratifying to all. I refer to the humanitarian view. The word "puddling" finds no place in the direct process. No such exhausting, overtaxing labour is demanded in any of its operations, and, as it is the truly scientific method of iron metallurgy, so does it, in common with all true science, point to the ultimate reconcilement of capital and labour.

I desire, before closing, to take this opportunity to acknowledge my indebtedness to my associate and co-labourer, Mr. Morrison Foster, of Pittsburg, whose assistance, from the first inception of my experiments up to the present time, has been of the greatest value to me.

Professor Egleston desired to know how complete the reduction was, how much oxygen remained in the sponge, and how the impurities common to iron ores were eliminated. He said that in the paper just read there were some severe remarks on the crude condition of iron metallurgy, especially the blast-furnace process. He desired to say that the blame did not lie at the doors of scientific metallurgists in this country. It must be remembered that most of the experiments abroad had government aid for their experiments, and government furnaces at their disposal to practise on. For the last thirteen or fourteen years he had endeavoured to make experiments on blast furnace gases, but had never been able to overcome the prejudice of furnace-men to having holes made in the stack of the furnace. Prof. Egleston spoke of some investigations made by Director Jüngst, of Gleiwitz, on the temperatures at which ores begin to lose oxygen in the blast furnace, and the temperatures at which reduction is complete. The temperature of incipient reduction is stated by Jüngst to be much lower than is generally supposed. Regarding the elimination of sulphur from coal by washing and coking, Prof. Egleston spoke of the works of the Orleans Railway, at Aubin, in the South of France, which he had studied, where a refuse coal containing 12 per cent. of ash and iron pyrites in large quantities, in lumps from the size of a hickory-nut to fine grains, was worked so as to contain only 3 per cent. of ash and 0·5 per cent. of sulphur.

Mr. Blair : We find 95 to 98 per cent. of the iron reduced. The impurities in the ore, as silica, alumina, lime, etc., are all contained in the sponge ; but, when the sponge is introduced into the bath of molten pig metal, the earthy ingredients melt and rise to the surface in the form of slag. In rich ores the amount of slag is not enough to cover the molten metal, and slag is added as such. In poor ores the amount of slag may be too large, and provision is made in the cinder-notch for tapping it off. The height of this notch is raised or lowered by means of fire-brick, according to the height of metal in the furnace.

Mr. F. Firmstone asked Mr. Blair what became of the phosphorus in the ore in his process.

Mr. Blair : We have made steel in crucibles from sponge made from Lake Champlain ores, which contained a large amount of apatite, and found no phosphorus in the steel. The case might be different where the phosphorus was combined with the iron in the ore.

Mr. Raymond remarked that it might make considerable difference if the phosphorus was combined with manganese in the ore. He had heard of a case recently, in which Bessemer pig was said to have been made from an ore containing 0·58 per cent. of phosphorus, and at the same time considerable manganese. It may be that phosphate of manganese is reduced with great difficulty, or that manganese will tend to carry off the phosphorus in the slag. He would like to ask Mr. Blair what became of the carbonic oxide escaping from his cylinders.

Mr. Blair : It is burned within the thimble to carbonic acid, and exerts no injurious influence on the workmen. He had had a few quite serious cases of poisoning with carbonic oxide arising from his gas-producers, and had invariably found ammonia (spirits of hartshorn), applied to the nostrils, a prompt and efficient remedy. When nausea is produced by inhaling carbonic oxide, a few drops of the aromatic spirits of ammonia give relief.

Prof. B. Silliman said that the question of the influence of manganese in smelting ores containing phosphorus was an interesting, and, to a considerable extent, an unexplored field. He had in mind a case where a spiegeleisen, containing 11 per cent. of manganese, and 0·1 per cent. of phosphorus, was said to be made from a spathic ore containing but 0·5 per cent. manganese, and 0·6 per cent. phosphorus. He thought that this could only be explained by the addition of manganese in some form to the charge, and in this connection the unexpectedly small amount of phosphorus in the spiegel was suggestive.

Mr. E. B. Coxe : The subject of poisoning by carbonic oxide is one of such great importance that I think that all possible publicity should be given to the antidotal effect of ammonia mentioned by Mr. Blair. I think it very probable that the "white damp" of the mines is carbonic oxide, and its fatal effects are well known to miners.

Mr. E. C. Pechin : I have listened to the very able paper read by Mr. Blair with melancholy pleasure. As a humanitarian I am delighted, as a pig-metal manufacturer I am in the depths of despair. I am placed in a position which must appeal powerfully to your sympathies. A few weeks since I was blown up by physical force—to-day I am blown away by scientific investigation. All my beautiful plans for new furnaces must be stowed away with the inscription, "What might have been if it hadn't been for Blair?" In behalf of the pig-iron makers of the United States, I appeal to Mr. Blair to follow the example of Dr. Siemens, to surround his process with such restrictions, and to charge such excessive royalties, that we may for this generation, at least, rather die by slow combustion than meet a violent and hasty death by carbonic oxide.

Mr. Blair reminded Mr. Pechin that he had used the expression that the old process will be *overgrown*, not *overthrown*.

Dr. Hunt expressed his pleasure at the results obtained by Mr. Blair, whose works near Pittsburg he had an opportunity of

visiting in November last. He felt a great interest in the question of iron sponge, from the fact that he had been the friend of Adrian Chenot, who had, in 1855, works in operation on a considerable scale at Clichy-la-Garenne, near Paris, and had assisted him in some of his experiments just before his sudden and accidental death at the end of that year. Chenot died with many of his plans unrealized, leaving behind him no one fully competent to carry on his work. Dr. Hunt testified that, notwithstanding the difficulties encountered, Chenot did succeed, at least with the readily reducible and porous Spanish ores, in obtaining a complete reduction, as the regular daily manufacture from the sponge of cast steel, which he had personally overlooked and followed, sufficiently showed. The apparatus of Chenot was essentially that of Mr. Blair, but there were practical difficulties in the way of heating the column which have been overcome by the latter by means of his simple and ingenious initial heater, in which the gas wasted from the top of Chenot's furnace performs the work of heating the ore in the upper part of the cylinder; while, by the happy device of using a mixture of charcoal in powder instead of in lumps, the difficulty of preserving the reduced ore from the influence of the air below is resolved. By these additions to the furnace of Chenot, Blair has continued and perfected his work.

But the ready production of iron sponge was but one part of the problem; its utilization was still more difficult. The conversion of the sponge into cast steel by cementation with oil and fusion in a crucible, as practised at Clichy by Chenot, was, at best, but a slow and troublesome method; and the attempt to weld the sponge into blooms, as tried at Clichy, and afterwards practised at Baracaldo, in Spain, was an expedient not easy of execution, and applicable only to very pure ores. The work of Chenot, of Gurlt, and of others, in making iron sponge, was in vain; the time had not yet come for its economic utilization, nor was it until the brothers Martin, with the aid of the Siemens gas furnace, succeeded in producing steel on a large scale in the open hearth from the fusion of soft iron with cast iron, that the true use of the sponge, as a substitute for puddled iron, was found.

This new process again turned the attention of inventors to the production of iron sponge, and three or four years since a reduction furnace, erected for the purpose at Westport, on Lake Champlain, succeeded in producing sponge which, at the Bay State Works, at South Boston, gave in the Siemens-Martin process a soft steel, with excellent results. This reduction furnace, which the speaker had examined, seemed, however, but indifferently fitted for its work, and was soon abandoned. The simple, cheap, and efficient apparatus of Chenot has, in the hands of Mr. Blair, received such improvements as made it, in the speaker's opinion, admirably fitted for the purpose of reducing iron ores to sponge. He regretted exceedingly that the beautiful and ingenious reduction furnace constructed by Mr. Edward Cooper, at Trenton, which many of the members of the Institute had an opportunity of inspecting in October last, was not already in operation, so that we might be enabled to judge of its practical efficiency. For the rest, the speaker entertained no doubt that the economic production of iron sponge, and its utilization in the open hearth, in accordance with the Siemens-Martin plan, was destined to be one of the great metallurgical problems of the future. One of the most important advantages of this process is the fact pointed out by Mr. Blair, that the mechanical impurities of the reduced ore are readily and completely eliminated by the process of dissolving it in a bath of molten metal. The iron is reduced to the metallic state without the reduction of phosphorus and silicon, and the compounds of these are not attacked by the metallic bath, which takes up the reduced iron as mercury takes up the precious metals in the process of amalgamation.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(100.)

THE Elements of Timber Construction.—*Centres.* The assemblage of timbers placed in an opening which is to be terminated at its upper part by an arch, and designed to support the bricks or stones of which that arch is composed, during the time in which they are built or placed together, is termed a "centre." When the arch is completed, and the mortar has had time to set, the centre is taken from below the arch, or, to use the technical term, the centre is "struck." In fig. 583 we illustrate a simple form of centre used for semicircular arches of small span, as arches to window and door openings. The walls terminating the opening on each side are indicated by *a a*, *a' a'*, the timber, the outer edges of which are cut to the radius of the arch, forming the semicircle. These timbers butt against each other at the point *b*, and rest at their lower ends upon the cross pieces, *c c*, supported by the uprights, *d d*, the lower ends

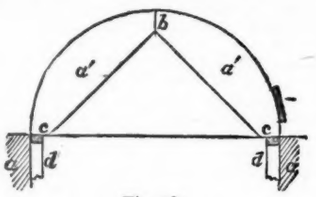


Fig. 583.

of which rest on the ground. Where the wall is not thick, a pair of the timbers, *a' a'*, are used, the second pair being in a line with the inside of wall, the two being joined by boards, as *f f*, stretching from one to another, and secured to *a a*. If the wall is very thick or deep, as in the case of a bridge, the pieces *a' a'* are more in number. For arches of wide span the centres are much more complicated than that shown in fig. 584, in which struts or braces, *a a*, are used, and a vertical strut, *b*, in addition to the side posts, *c c*. The ribs, *a a*, three or four in number, support transverse timbers, or "bolster pieces" *e e*, upon which the bricks

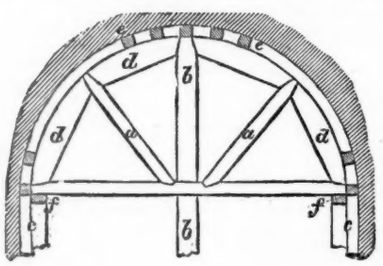


Fig. 584.

or stones forming the arch are placed. When the centre is to be struck, the wedges, the ends of which are shown at *f f*, are struck partially out, allowing the centre to be lowered, and the arch to settle gradually. When the arch is to be finally struck, the wedges are struck wholly out, and the supports, *b b*, *c c*, taken down and the centre removed. In fig. 585 we illustrate another method of making the ribs of a "centre." The two pieces, *a b*, butt at the joint *e*; this is covered by the solid or central part of the third piece, *d*, placed behind *a* and *b*, the butting joints of which are at *e* and *f*; the diagram to the right shows the pieces in side

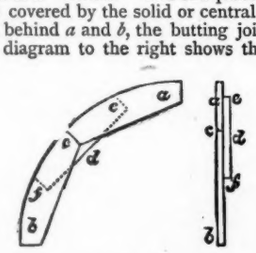


Fig. 585.

view. Where vertical posts cannot be admitted, as *b b*, *c c*, in fig. 584, to support the centre, the assemblage of timbers composing it is much more complicated in detail and design than those shown in fig. 584, the object being to make the centre self-supporting, and to bear the weight which it has to carry. We shall in a future note give examples of such.

Trussed Beams. In figs. 586 and 587 are given sketches of what are termed "trussed" beams, the object in trussing being the strengthening of the beams. Fig. 586 is on the principle of the "king post" truss for a roof. Two beams are used, as *a a*, *b b*, in the lower diagram, these being secured together by bolts and

nuts as at the points *c c* in upper diagram. A central stud, or bolt, *e*, provided with a rounded end, *f*, is secured between the two beams, *a a* and *b b*, by passing through the top plate, *g*, of wrought iron, and secured by the nut, *h*. A wrought-iron truss-rod, *i i*, is passed round the lower and grooved side of *f*, and up between the beams and through butting-plates, *j j*, at the ends of the beams, and secured by nuts to the screwed ends of the rods. In fig. 587 a trussed beam is illustrated as arranged on "queen post" principles, two studs, *a a*, being used, the truss-rod, *b b*, passing between them as shown.

(101.) **Beams Horizontal and Inclined, and the Strains to which they are subjected.**—We purpose presenting to our readers, on this important subject, from time to time, a few notes, which we trust will be practically useful.

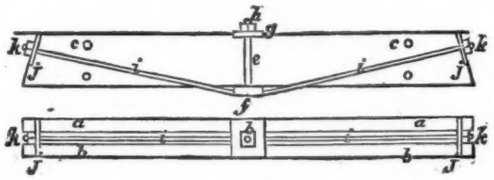


Fig. 586.

In the limited space at our disposal, we can obviously give but the outlines of the subject, taking care, however, to present them in such a way that they will not only be useful in themselves, but serve as an incentive to the student to take up the subject in works specially devoted to it. The subject is one of increased and increasing importance, and deserves, as it should obtain, that careful study at the hands of the student and workman anxious to advance in the world, and to find at the end of any one year, or marked period of life, he is "higher up the social scale" than when he began it. It will be our pride and gratification to know, as it will be the object of our ambition to aid in such a matter, that anything we have done shall have been the means of urging on the student and workman to this honourable ambition. If we do no more than this, we shall have done well. The main portion of the remarks on horizontal beams was given some two years ago in the pages of this journal; but in order to make the subject complete, and under one head, we have deemed it best to reproduce them.

(*a*). *Horizontal Beams.* When a beam is supported at both ends, and acted upon by a weight, either resting upon its upper surface or suspended by a rope or chain from its lower surface, the resistance which the beam affords or gives to the action of the weight to break it, is called its resistance to "transverse" or "cross" strain or pressure. (*b*) When a beam is so placed that the pressure exerted upon it is calcu-

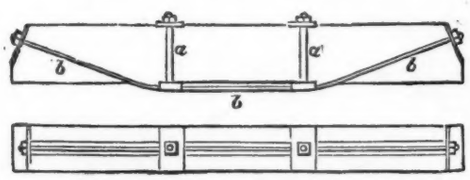


Fig. 587.

ated to tear asunder its fibres, it is said to be subjected to a "tensile strain." (*c*) When a beam is placed, as in a pillar or column, so that the pressure is exerted to crush the fibres, it is said to be subjected to a "compressive strain." (*d*) When a beam is supported at both ends, and the pressure is exerted at any point between the points of support, the beam has a tendency to bend downwards in the centre, as shown by the dotted line, *a*, in fig. 587, the bend is called the "deflection," and its power to resist this is called its "resiliancy" or its "elasticity." (*e*) When a beam is placed as in the case (*a*), the upper half is subjected to a "compressive," the lower half to a "tensile" strain. The central line of the beam is called the "neutral axis." (*f*) The strength of a beam varies not only with its form, but in the way in which it is placed, the distance between the supports, and upon the distribution of the load over its surface. The strength of a beam rectangular in section is in proportion to the square of its depth, this being multiplied by the breadth or thickness, and divided by the span or distance between the supports. Stated otherwise, the strength of rectangular beams to resist cross pressure or strain increases as the square of their depth, and directly as their breadth or thickness. Thus a beam of a given breadth has its strength only doubled if its breadth or thickness be doubled only, the depth remaining the same. But, if its depth be doubled, the breadth or thickness remaining the same, its strength is quadrupled, that is, its strength is increased as the square of the depth. By merely placing a rectangular beam, that is, a beam which has a greater depth than breadth or thickness in section, upon its edge, instead of upon its side, the strength of it is quadrupled as compared to that which it has if placed on the flat (*g*). The strength of a beam is dependent upon the distance between the supports; the longer, then, the beam, the weaker it is; the strength of beams

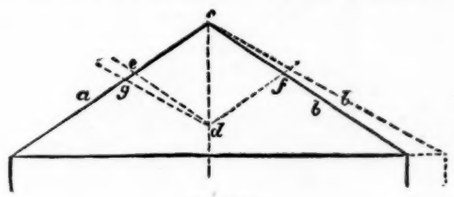


Fig. 588.

is "inversely as the span" (*h*). The distribution of the load on a beam influences its capability to resist strains. A beam which has its load uniformly distributed over its whole surface will bear a pressure twice as great as the same beam with its load acting upon the centre of the beam; the nearer the weight or load of the beam approaches the point of support, the less is the pressure exerted on the beam. A beam, therefore, may be reduced in depth towards the ends where these approach the points of support without decreasing its strength, the strongest form being that in which the lower side assumes the curve of a parabola, the depth at the ends being half of the depth at the centre (*i*). A beam supported at one end only, or projecting from the face of a wall, will be as strong if the depth at the outer extremity is reduced to a point, the curve of under side being parabolic, as where the depth is uniform throughout. The effect of the disposition or distribution of the load in a beam thus supported at one end only is similar to that explained in (*f*), the projecting beam supporting a double load if the weight is distributed uniformly over its surface, as compared with the beam loaded on its outer extremity.

(102.) **Methods to ascertain the Pressure to which Inclined Beams are Subjected.**—(*a*) To find the pressure on the inclined beams *a b*, fig. 588, the weight to

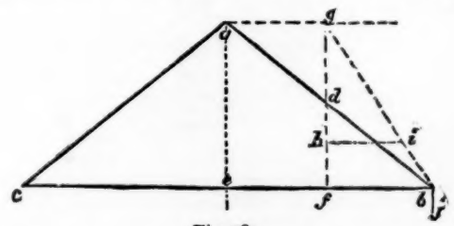


Fig. 589.

which they are subjected on the apex *c* being given. Let *a b* be the beams, placed at equal angles on each side of the central line *c d*, and assume 16 cwt. to be the weight of the body resting on the apex *c*, or the pressure to which that point is subjected. From *c* drop a perpendicular line *c d*, and from any "scale of equal parts" take in the compasses a distance equal to 16—the number of cwts. pressing upon *c*—and set it off from the points *c d*. From *d* parallel to the beam *b* draw a line cutting the line *c a* in the point *e*, the distance, *c e*—measured from the same scale of equal parts from which *c d* was measured—will give the number of cwts. to which the beam *a* is subjected, namely, 14. The pressure sustained or distributed by the beam *b* will be the same as that by beam *a*; but this united pressure will be greater than the pressure on the point *c*, this united pressure increasing as the angle of the beams *a b*, or the distance between their lower extremities increases. Thus, if the inclination of beam *c b* was *c h*, the line *d g*, or 15, would represent the pressure in

place of *d e*, 14. The pressure on inclined beams, therefore, varies with the inclination at which they are set; the nearer they approach the perpendicular the less is the pressure sustained by them, or the stronger they become, or rather the greater the weight which they will carry. A beam laid horizontally is in the weakest position in which it can be placed; this, however, greatly depends upon the material of the beam, and the peculiar kind of strain to which it is subjected.

(*b*). In the case last illustrated the weight acting on the beams *a b*, the pressure is transmitted in the direction of the length of the beams, and the line of pressure is therefore easily enough ascertained; but as inclined beams are generally employed in

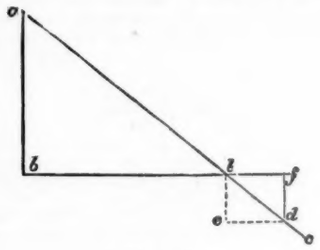


Fig. 590.

roofs, and as the roof-covering material which they carry—as slates, tiles, &c.—is distributed regularly over the length of the beam, the line of pressure is not in the same direction as in the case illustrated in fig. 588. To find the direction of the pressure on the line of thrust on the wall tending to press it outwards proceed as follows:—Let *a b*, *a c*, fig. 589, be the two inclined beams forming the roof. Find or assume the position of the centre of gravity in one of these as the point *d*, from *a* drop a perpendicular *a e*, and parallel to *a e* draw through the point *d* a line *g d f*. From *a* draw a line *a g*, cutting *f d g* in the point *g*, from *g* draw a line joining the point *b*; the line *g b* gives the direction of the pressure on the beam *a b*. To find its amount:—Having calculated the weight of the materials which the beam *a b* is to carry, which we shall assume is represented by the number 19—take 19 parts from any scale of equal parts, and measure it from the point *g* to the point *h* on the line *g d f*. Parallel to *a g* from *h* draw the line *h i* cutting the line *g b* in *i*, measure the distance *h i* from same scale, this will give the pressure on the beam *a b*, and which will be found to be 12, this being the amount of pressure which the beam *a b* exerts, tending to shore into the walls in the direction of the line *g b*. The use of the beam is to obviate the effects of this outward thrust of the beam *a b*, fig. 589, upon the wall *j*, and to make the pressure in the wall as

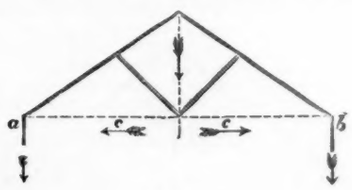


Fig. 591.

vertical as possible, the materials of the wall being best competent to withstand a directly vertical pressure. But the pressure of the beam *a b* in fig. 589 will be acting in the direction of *g b*, tending to thrust out the wall *j*, and will still act to a certain extent vertically. To resolve this twofold pressure, exercised by the beam *a b*, into its two component parts, and to ascertain the amount of each of these, proceed as follows:—Let *a b*, fig. 590, be the beam, produce it in the direction *a c*, making *a d* equal to the pressure on the beam, from *d* draw a line *d e* parallel to *b b*, and from *d* to *f* parallel to *a b*. The distance *b f*, measured from the same scale of equal parts, will give the horizontal pressure; *b c* the vertical.

(*c*). The trussed roof, as in fig. 591, and also in fig. 507 (see note 93 in the January No. of "Practical Magazine" for 1875), is the strongest combination or form—the triangle—in which materials can be placed and the best for resisting the pressure which the various beams exert, into a vertical pressure upon the walls, *a b*, fig. 591, in the direction of the arrows. In this the parts shown in thick lines are all subjected to strains of "compression; the parts in dotted lines are those subjected to strains of tension. To ascertain the pressure tending to tear asunder the tie *c c* in the direction of the arrows, proceed thus: let *a b*, *b c*, fig. 592, be the beams, *a c* the tie beam; from *b* drop a perpendicular *b d*, make *b e* equal to the pressure on the beams, from *e* draw *e f* parallel to *a b*, from *f* draw *f g* parallel to *a a*; *f g* will be the measure of the pressure required.

(*d*). Where two inclined beams are given, to find the direction of a third beam best calculated to resist the pressure. Let *a b*, *b c*, fig. 593, be the two beams; *a b* being subjected to a pressure represented by the distance 9 10, and *b c* by 19 18. Produce *a b* to *e*, and make *b g'* equal to 9 from any scale of

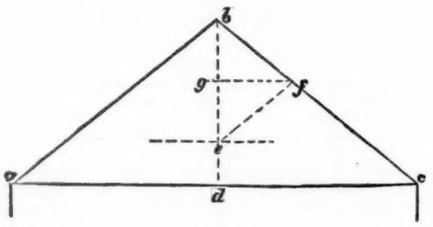


Fig. 592.

equal parts. Produce *b c* to *d*, and make *b f* equal to 18; from point *g* draw lines *g h* parallel to *b c*, and from point *f*, *f h*, parallel to *a b*, acting on the point *h*. Draw the diagonal *b h*, this will be the required direction of the third piece *h i*, and the distance, *b h*, will be the pressure to which it is subjected, or 23.

(*e*). When two beams are placed in relation to a wall, as the beam *a b*, *b c*, fig. 594, projecting from the wall *d d*, the pressures to which each is subjected by a weight acting from the point *d* in a vertical direction are ascertained as follows:—Drop from the point *b*, fig. 594, a line *b e*, making *b e* equal to the pressure in weight, as 18; from *e*, parallel to the piece *c b*, draw a line *e f*, cutting the piece *b f* produced in *f*; from *e*, parallel to *a b*, draw a line *e g*, cutting *b c* in *g*. Draw the diagonal *g f*, the dis-

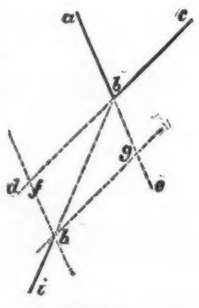


Fig. 593.

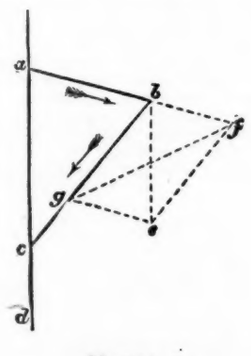


Fig. 594.

tance will be the reverse of the pressure, tending to pull the piece *b c* out of the wall in the direction of the arrow, the distance *b g* thus tending to press the wall inwards at *c*. The piece *a b* acts as a tie, and the piece *b c* as a strut or brace.

(*f*). All pieces or members of framing, which act as "ties," might be formed of lengths of ropes, chains, or iron rods, calculated to bear a tensile strain. The struts or braces must be made of material calculated to bear a compressible strain, as of timber or iron. To ascertain whether the member of a framing acts as a "tie or strut," proceed as follows: let the point of purchase of the two members, as *b* in fig. 594, complete the parallelogram as there shown, the manner of finding the length of the sides of this, in all cases, has been amply illustrated by this and by the diagrams from fig. 588 to this of fig. 594. If, then, a side of the parallelogram, as *e f*, parallel to one of the beams, as *c b*, cuts when produced the central lines produced of the other beams, as *a b*; then this other beam acts as a tie. If the lines *e g* of the end of the parallelogram, and parallel to the piece *a b*, cuts the other piece, or *b c*, that piece *b c* is a strut.

REPORT OF THE FRENCH ACCLIMATIZATION SOCIETY FOR 1874.

OUR survey of industrial progress abroad would be incomplete without some reference to the labours of the French Acclimatization Society, whose last annual report, just published, is now before us. But our space is limited, and we must be brief, touching only upon such topics as are more immediately connected with the subjects to which the magazine is specially devoted.

Although the Acclimatization Society had to deplore the loss, during the year in question, of many valued associates at home and abroad,—of Elie de Beaumont, the Academician, General Baron Girod, an eminent French agriculturist, the Count de Kergolay, Cordier, Reintjens, De Soubeyran, and other earnest workers who have passed away from the scene of their labours,—its efforts, the report tells us, have been no less prolific of results than in former years.

In connection with the question of the possibility of increasing the number of animals in the service of man, the successful breaking-in to draught of a team of Burchell's Zebras, in the Bois de Boulogne, is cited, in proof that the utilization of new animals any wise adapted for domestication is a mere question of time and patience. The success of the experiment amply confirms the assertion made by Cuvier long ago, that the surest way to domesticate wild creatures is to win their confidence, not to inspire them with dread. It would be well if the rule were more often observed in dealing with individuals of species already domesticated. M. Cornély, a very active member of the Society, has paid much attention to the acclimatization of the kangaroo. In his park at Beaujardin, near Tours, he has now a large flock of these animals running wild. They breed freely, and stand the climate perfectly well. Preserved kangaroo-tail soup may now be found in most provision warehouses, and kangaroo skins from Victoria, we learn from a trade contemporary, are in brisk and increasing demand in the London leather market. But that kangaroo-breeding is ever likely to pay in Europe, or the animals to be anything beyond a picturesque but troublesome addition to the game-preserve, as they proved themselves at Glastonbury and one or two other places in England some years ago, is, we should think, rather more than doubtful.

The successful attempts at ostrich-farming in the western districts of the Cape of Good Hope have led to similar attempts in Algeria. After many failures, a French officer, Capt. Crépu, has obtained results which are held to be encouraging.

The use of horse-flesh as food, which the Society has done its best to encourage, is stated to be on the increase in France. M. Vavin reports that in Brittany, especially in the neighbourhood of Morlaix, horses are fed largely on parsnips. They eat them with avidity, and do well upon them. It is suggested that the plan might answer elsewhere. Through the efforts of M. La Perre Roo and other Belgian authorities, France has now a military pigeon-establishment stocked with over four hundred of the finest and best-bred courier pigeons in the world, the produce of which will be distributed to form branch establishments, for military postal purposes, in all the principal French fortresses.

The Society's ornithological acquisitions have been very numerous; amongst them may be mentioned the wild turkey, which, it is said, will prove a profitable substitute for the domestic bird. In connection with this portion of the subject, we may note the utilization of beech-mast for rearing pheasants, a purpose for which it is recommended by Dr. Moreau. The improvement of the fish supplies has received much attention from the Society. At its instance, the Minister of Marine has ordered the formation of shell-fish beds in various parts of the coast. Pisciculture has received a large share of attention. The experiments of M. Rico have proved that it is possible to rear salmon in waters without an outlet. Numerous consignments of exotic fish have been received from the United States and China, with a view to their acclimatization in the streams of France and Algeria. M. Dabry de Thiersant, French consul at Canton, has sent home a collection of the so-called "domestic fish" from China. Hopes are entertained also of the acclimatization of the *gourami*, a Chinese fish of the highest epicurean repute, in Algeria. We may here observe that many years ago, when the very name of pisciculture was yet unknown, this fish was successfully introduced in the island of Mauritius.

Sericulture is the subject of many valuable communications, which appear in the Society's Bulletin. M. Hignet, of Warsaw, points out the advantages of feeding silk-worms on the leaves of the wild mulberry, instead of those of the cultivated species. He believes disease amongst the worms to be the result of unsuitable food, rather than of climatic influences. M. Le Doux and Dr. Forgemol suggest an ingenious method of utilizing the produce of exotic species unsuited for acclimatization, as the magnificent Brazilian *Attacus aurota*, with the aid of artificial cocoons formed of india-rubber. Dr. Odstreil communicates the result of some experiments with *Attacus Pernyi* in Austria. The results of experiments with *Attacus Yama-maï* (Japanese silk-worm), in various parts of France, in England, in the Baltic Provinces, and in Spain are detailed.

In connection with the vegetable kingdom, the communications are very numerous. Various hardy species of Bamboo have been introduced in France, and are found to do well. Experiments have been made with the various Australian gum-trees (*Eucalyptus*), to test their qualifications as timber trees, and as preventatives of malaria. Attention is called to the superiority of the English "imperial" cabbage over the kinds usually grown in French gardens. *Lippia Ægyptiana* is recommended for the formation of lawns and ornamental grass-plots in hot climates, where the formation of ordinary greensward is a much-coveted impossibility. The feasibility of introducing the cacao-tree, *Erythroxyle*, into French Guiana, is discussed. Last, but not least, amongst the papers in the Society's Bulletin, is to be noted a memoir by the late Dr. Laval, on *Silphion*, a reputed specific for phthisis, from Tripoli—an acquisition for which the collector paid with his life. Looking at the immense amount of useful work that has been done by the members of the Society, both collectively and individually, we can here re-echo the sentiment conveyed in the concluding words of the report, and express a hope that the past may be an earnest of continued effort in the future.

METALLINE—A NEW ANTI-FRICTION COMPOSITION.

METALLINE is a substance resembling in appearance plumbago. It is manufactured solely by the American Metalline Company, 61, Warren Street, New York. Its composition is at present kept secret, but an analysis given in the "Practical Magazine" for September, 1875, on the authority of "Dingler's Polytechnisches Journal," shows it to contain

Fig. 2.

lead, zinc, carbon, silica, paraffine, lime, iron-oxide, magnesia, and tin. It is applied to bearing surfaces as a preventive of friction. However highly polished such surfaces may become with wear, examination with a glass of adequate magnifying power proves them to be full of small asperities, which lock into each other,

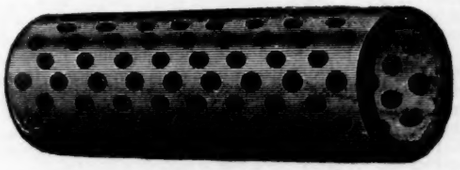


Fig. 3.

thereby causing friction, with its necessary concomitants, loss of power and increased wear and tear. Theoretically, metalline is held to form an impalpable powder, which fills up all such irregularities, thereby reducing the friction of the surfaces to which it is applied to a minimum.

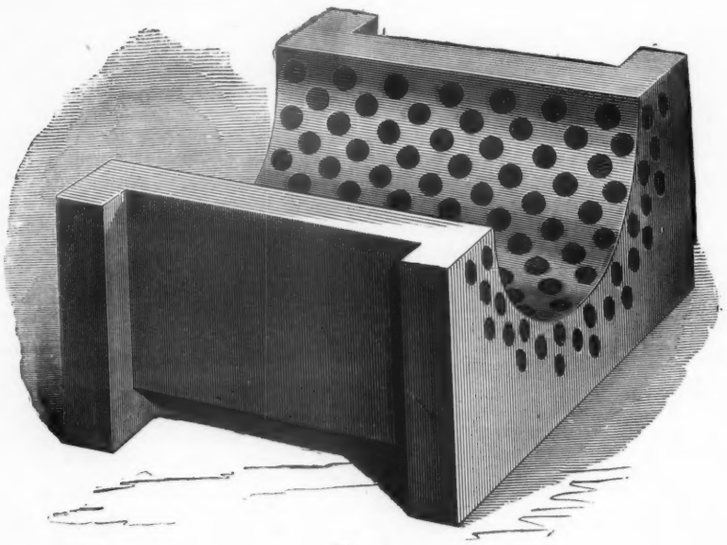


Fig. 1.

The composition was invented by Mr. Stewart-Gwynne, and was first tried in 1868. From various causes it remained in abeyance until 1873; since then, however, it has been extensively used for machinery, and has been found to give very satisfactory results. The method of application is shown by the annexed figures, for which we are indebted to the "Moniteur Industriel Belge."

Fig. 1 illustrates its application to a crank-pin bearing. For all large bearings it is best to drill a number of small holes 3 to 8 millimetres ($\frac{1}{10}$ to $\frac{3}{10}$ in.) in diameter, and 3 to 5 millimetres ($\frac{1}{10}$ to $\frac{2}{10}$ in.) deep on the interior surfaces, and plug them with small cylinders made of the composition. Each cylinder is sent home with a light tap of a jeweller's hammer, and the whole is then surfaced with the file. Fig. 2 represents one of these cylinders.

In tubular bearings, holes cannot of course be made in this way; a cylindrical lining of gun-metal 3 to $4\frac{1}{2}$ millimetres in thickness, plugged with metalline from the outside, as in fig. 3, is then used.

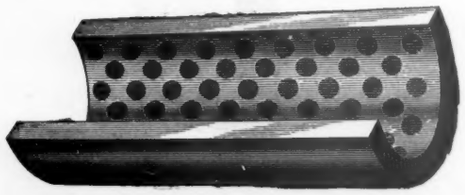


Fig. 4

With very small bearings. the metalline may be applied to the bearing surfaces in powder; but in those exceeding $2\frac{1}{2}$ in. in diameter it is best to use half-linings of gun-metal, as in fig. 4.

With gun-metal bearings the composition may be used as above. Iron and Babbett's metal require to be lined with gun-metal. It has been found that, where metalline is used, the bearings may be shorter than where oil is employed. It is seldom necessary that the length should exceed three times the diameter. If longer, they should be countersunk in the middle, so that the breadth of the surface in actual contact may not exceed the above proportion. The following precautions are recommended for observance where metalline is used:—

1. If oil has been previously employed, the bearings should be thoroughly cleaned with benzine or spirits of turpentine.

2. Water or oil should never be allowed to reach a surface where metalline is used, unless it be for some specific object.

3. A certain time is necessary for the effects of the metalline to make themselves felt, and during this interval a considerable amount of heat may be developed. But metalline will stand a temperature of 110° C. (230° Fah.), and the heat rarely increases after half an hour's running, it generally decreases.

4. The axles should run easily in the bearings, especially at starting.

5. If all is well at starting, the bearings need not be examined oftener than once a month. Cases have been known where they have been kept running for years without opening. They should never be opened while hot.

The advantages claimed for the composition are that it reduces friction, saves the cost of lubricants and the time expended on their application, lessens the risks of fire, and ensures cleanliness, by the absence of oil and grease,—a consideration of no small importance in many industrial processes.

COMPARATIVE STATISTICS OF THE ENGLISH AND PRUSSIAN RAILWAYS IN 1873.

THE "Journal of the Association of German Railway Companies" has just published comparative statistics of the English and Prussian railways in 1873, which we now intend to reproduce for reasons that it will afford us means of easily comparing our railway management with that of Prussia. The English railway statistics are announced as being based on the railway returns presented to Parliament.

The railway mileage of Great Britain pro end of 1873 was 25,892 kilometres (= 16,078·9 miles), that of Prussia, however, 13,755 kilometres (= 8,541·9 miles); of the former, 13,986 kilometres (= 8685·29 miles) were laid with double or more rails, of the latter only 5,349 kilometres (= 3,321·73 miles), were laid similarly.

This railway mileage with regard to the size and population of the two countries, is divided as follows:—

	Great Britain.	Prussia.
Railway mileage in kilometres .	25,892	13,755
Superficial area in geographical square miles	5,719·8	6,304·9
Population at last census . .	32,131,488	24,693,274
Railway kilometres, per one square geographical mile . . .	4·53	2·18
Railway kilometres, per 10,000 inhabitants	8·06	5·58

The respective capitals used were: for Great Britain, 588·3 million sterling, or, 22,731 sterling per kilometre; for Prussia, 162·6 million sterling, or 11,931 sterling per kilometre; that is to say, about double as much was paid per kilometre in Great Britain as was actually paid in Prussia.

The comparative statistics of the rolling stock in both countries are given in the following summary :

	Great Britain.	Prussia.
Locomotives	11,435	5,173
Ditto, per kilometre railway	0·44	0·36
Passenger compartments	24,634	7,816
Ditto, per kilometre railway	0·95	0·54
Luggage vans	9,128	1,933
Ditto, per kilometre railway	0·35	0·14
Cattle and goods trucks	323,701	113,650
Ditto, per kilometre railway	12·50	8·25
Working stock	5,322	3,153
Ditto, per kilometre railway	0·20	0·23
Total, exclusive of the locomotives	362,785	126,552
Ditto, per kilometre railway	14·01	9·16

In Great Britain the trains ran over 317,731,346 kilometres, or 12,230 kilometres over each kilometre of rail laid down pro end of 1873 ; in Prussia the trains travelled over 94,792,921 kilometres, or 6891 kilometres per kilometre rail. Consequently on an average the various distances have been travelled over 33·5 times per day in England, and nineteen times per day in Prussia.

The comparative receipts and expenditures were as follows in 1873 :—

		Pro Kilometre travelled.	Pro rail. Kilometre.
Total receipts	Great Britain = 55·6 million sterling	3·50s.	£2,151·6.
	Prussia = 24·3 „ „	5·16s.	£1800·6.
that is to say, in Prussia	more	1·66s.	.....
	less	.....	£351·0
Total expenditure	Great Britain = 30·05 million sterling	1·89s.	£1,159·7.
	Prussia = 16·95 „ „	3·56s.	£1,242·9.
that is to say, more in Prussia by		1·67s.	£83·2.
Clear profits	Great Britain = 25·6 million sterling	1·61s.	£991·95.
	Prussia = 7·5 „ „	1·60s.	£557·70.
or less in Prussia by		0·01s.	£434·25.

The foremention data show that in Prussia each kilometre of rail laid was only travelled over half as much as was the case in England for the corresponding period, and that, whereas the gross receipts on Prussian railways was only 47·4 per cent. larger than in England, the total expenditure of the former already exceeded the English railway gross expenditure by 88·4 per cent. If the wear and tear of the rolling stock be assumed to be equal in both countries, then the last-mentioned figures would prove that either the average carriage (gross receipt per ton and kilometre) was less, or the cost of repairs and management was greater in Prussia than in England. The passenger fares were greater in England than in Prussia. The English railway statistics unfortunately do not afford exact means of computing the relative carriage tariff rates.

The clear profits per kilometre travelled are almost identical with each other in both countries. The clear profits per kilometre of rail is 16·3 per cent. less in Prussia than in England, the corresponding expenditure 7·2 per cent. greater, and the clear profits 44 per cent. smaller.

The total expenditure on English railways was 54 per cent., on Prussian railways 69 per cent. of the total receipts.

In 1873, 455·3 millions of journeys were made by rail in England, exclusive of the contract holders, which yielded 20·11 million pounds sterling, against 99·6 million journeys, accompanied by 6·14 million pounds sterling receipts in Prussia. Of these the percentage of the different classes was—

		1st Class.	2nd Class.	3rd Class.	4th Class.	
Great Britain	Number of journeys in percentage	8·4	15·9	76·2	none	= 100
	Receipts in percentage	21·8	19·8	54·4	none	= 100
Prussia.	Number of journeys in percentage	1·5	15·3	52·9[1]	30·3	= 100
	Receipts in percentage	7·5	32·6	41·3	10·6	= 100

Consequently, on an average, 14 journeys are made annually per inhabitant in Great Britain, against 4 journeys annually per head in Prussia. The average fare per journey amounted to 1·05 shilling in England, and to 1·30 shilling in Prussia. On an average 35·6 kilometres were travelled over by each railway traveller in Prussia ; the corresponding English ratio is not given.

In minerals and other merchandise were forwarded—

	Great Britain.	Prussia.
Tons.	194 millions	89 millions.
Average tonnage per kilometre rail	7,493 tons	6,490 tons.

The average receipt per ton of minerals and other merchandise (excluding secondary items of receipt) amounted to 3·16 shillings in Great Britain, and 3·40 shillings in Prussia. The average distance travelled over by each ton of such merchandise was 82·8 kilometres in Prussia ; the English statistics are silent on the point, so that the comparative average carriage cannot be deducted.

[1] Including military transports.

The ratio of receipts from the passenger and merchandise trains was in percentage for

	Great Britain.	Prussia.
Passenger trains	43	29
Goods trains	57	71
	100	100

The average dividends for the year 1873 were—

(*a*) For the original share capital (Stammactien capital) :

In Great Britain = 4·99 per cent.

Prussia = 5·44 „ non-guaranteed.
Prussia = 5·94 „ guaranteed.

(*b*) For the subscribed capital (Gesammte capital) :

In Great Britain = 4·64 per cent.

Prussia = 4·64 „ non-guaranteed.
Prussia = 4·93 „ guaranteed.

These figures include the capital which bore no interest or dividends in 1873, and which amounted to 46·085 millions sterling, or 7·83 per cent. of the whole railway capital in Great Britain, and 8·105 million sterling, or 4·98 per cent. of the whole railway capital in Prussia.

Comparing the railway results of 1873 with those of the preceding years we obtain the following statistical table :—

Per kilometre travelled.

	Great Britain. Receipts.	Great Britain. Expenditure.	Great Britain. In per cent. of the receipts.	Prussia. Receipts.	Prussia. Expenditure	Prussia. In per cent. of the receipts.
1870	3·19s.	1·55s.	49 o/o	5·39s.	3·02s.	56 o/o
1871	3·27s.	1·57s.	48 o/o	5·70s.	3·36s.	59 o/o
1872	3·34s.	1·67s.	50 o/o	5·23s.	3·40s.	65 o/o
1873	3·50s.	1·89s.	54 o/o	5·16s.	3·56s.	69 o/o

Per rail-kilometre.

1870	34,630s.	16,865s.	49 o/o	31,493s.	17,648s.	56 o/o
1871	38,085s.	18,285s.	48 o/o	33,426s.	19,716s.	59 o/o
1872	40,323s.	20,161s.	50 o/o	34,245s.	22,274s.	65 o/o
1873	43,033s.	23,194s.	54 o/o	36,012s.	24,858s.	69 o/o

The gross receipts increased from 1872 to 1873 : in Great Britain, from £51·304 millions to 55·675 millions = £4·371 millions or by 8·5% or by 0·163 shillings = 5% per kilometre travelled, or by £135·5 or 6·7% per rail kilometre. In Prussia, £21·835 millions to £24·509 millions = £2·6735 millions, or by 12·2% ; decreased by 0·074 shillings = 1·4% per kilometre travelled ; increased by £88·35 or 5·1 % per rail kilometre.

In the English passenger traffic the receipts and number of persons increased in the 1st and 3rd class, but decreased in the 2nd. This increase and decrease in 1873 against 1872 was as follows :—The receipts of 1st class increased by £54,089 ; of 2nd class decreased by £213,330 ; of 3rd class increased by £1,431,827 : the number of passengers, 1st class, increased by 632,216 ; 2nd class decreased by 2,132,134 ; 3rd class increased by 33,945,284.

The considerable decrease of 2nd class passengers in favour of the 3rd class is accounted for by the introduction of 3rd class carriages to all trains ; it shows that the fare of the 2nd class in comparison to its comfort was too high, and at the same time the increase of the 3rd class displays the elasticity of this travelling class. With regard to the punctuality of express trains, the results have been less satisfactory.

In Prussia, on the other hand, an increase has taken place in 1873 on 1872, both in the number of persons conveyed, and in all the four railway classes.

	1st Class.	2nd Class.	3rd Class.	4th Class.
Increase of receipts	£23,713·35	£125,724·9	£314,312·55	£223,504·2
„ number of passengers	133,503	1,609,839	7,613,389	5,141,995

The goods receipts from 1872-73 increased by £2,804,970 in England, that is, at the rate of 9.6 per cent., and by £2,248,007.7, or at the rate of 16 per cent. in Prussia.

The cost of line maintenance per kilometre travelled in both countries has been on the increase ever since 1870 ; it was largest in England from 1872-3, and heaviest between 1870-1 in Prussia. The English cost of line maintenance per kilometre travelled rose from 0·318 shilling to 0·37 shilling, or increased by 0·052 shilling between 1872 and 1873 ; in 1870-1 the same cost of maintenance in Prussia rose from 0·783 shilling to 0·823 shilling, or increased by 0·045 shilling.

The cost of locomotive power and maintenance of rolling stock per kilometre travelled increased in Great Britain by 0·118

shilling (from 0·606 shilling to 0·724 shilling); the entire cost of the Prussian railway management rose by 0·123 shilling, from 1·695 shillings to 1·818 shillings.

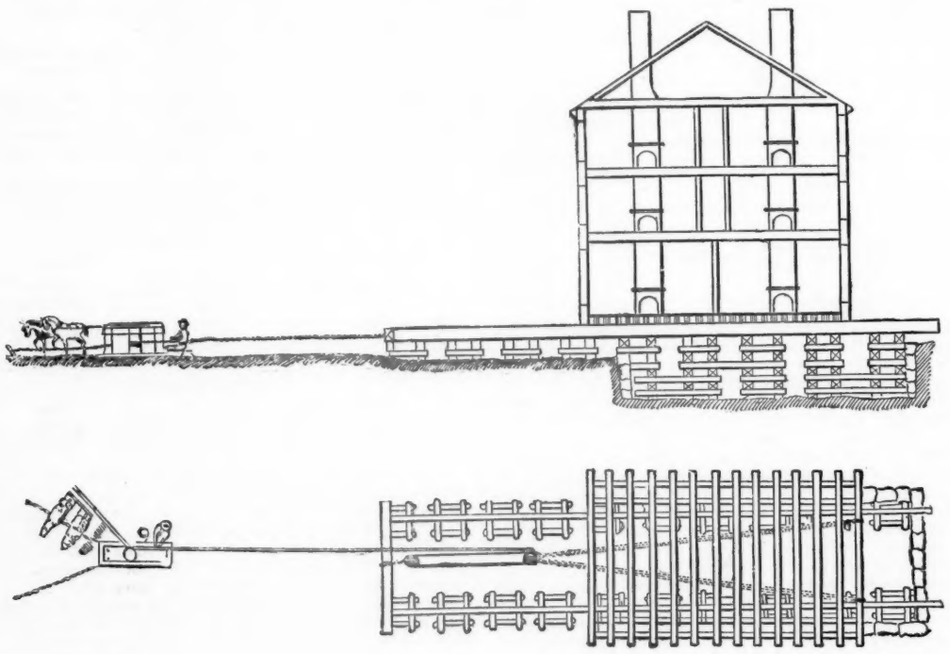
The cost of firing materials was as follows in Prussia:—During the whole of 1873 = £1,621,261·5, 0·31 shilling pro locomotive, effective kilometre or 0·072 shilling pro 1,000 brutto cwt. kilometre; 1872 = £1,166,019, 0·26 shilling pro locomotive, effective kilometre; or 0·062 shilling pro 1,000 brutto cwt. kilometre.

The entire English costs of maintenances increased from 1873 on 1872 from £25·653 millions to £30·06 millions = £4·407 millions = 17·2 per cent.; per kilometre travelled, by 0·223 shilling = 13·2 %; per rail kilometre by £151·65 = 15%.

The corresponding Prussian costs increased from £13·804 millions to £16·9585 millions = £3·1545 millions = 22·8 per cent.; per kilometre travelled by 0·158 shilling = 4·6 %; per rail-kilometre by £129·2 = 11·6 %.

The year 1873 consequently shows an increase in both countries with regard to the receipts per rail-kilometre, but a much greater increase in the corresponding expenditure.

Compared with 1858 the gross receipts in England rose from £23·955 millions in 1858 to £55·675 in 1873, or increased in these fifteen years by 132 %, or by 38 % pro rail-kilometre, whereas the rail-mileage increased by 41 %; the Prussian corresponding figures are from £5·265 in 1858 to £24·505 in 1873, corresponding to a percentage of 365 and of 101 % pro rail-kilometre, and to a total rail-mileage increase at the rate of 190 %. Between these fifteen years, therefore, the Prussian railway net had developed itself in a considerably greater ratio than was the case with England, but it must be remembered that the English railways prior to the period referred to had already received greater development than had been bestowed on Continental railways.



MOVING BRICK HOUSES.

By Charles S. Close.

WE extract the following Account from the "Journal of the Franklin Institute." It may interest some of the readers of the "Journal" to have a short description of the manner of moving brick houses from one location to another, as recently effected in this city.

A good and substantial three-story dwelling, measuring 30 feet by 18 feet on the plan, and about 30 feet height of walls to the eaves, was erected on the farm of Henry Myers, in the southern part of the district of Southwark, about twenty years ago. This building (with a portion of the farm) was recently sold to the Frankford and Southwark Railroad Company. When the company commenced to build their southern terminus depot, they concluded to move the dwelling house to the line of Fifth Street, a distance of nearly 400 feet.

The first step was to break holes through the side (9 in.) walls on the level of the under side of the ground floor, between every other pair of floor joists, which were about 16 inches, centre to centre, or 13 inches apart. Through these holes rough yellow pine timbers, 12 inches square by about 25 feet long, were inserted, which were thus 2 feet 8 inches, centre to centre. These timbers were brought up into contact with the floor, and keys were driven on top of them to support the side walls. The front and back walls were carried by needles, and two timbers parallel to the cross timbers were laid in line of the walls, and after blocking up on top of these timbers, the needles were removed. The ends of all the timbers were then braced apart by blocking fitted between each pair, until the whole formed a cradle.

The lifting was effected by jack-screws near the end of each timber, about two feet outside of the walls, fifteen (three nests or sets of five each) on each side. The jack-screws were set tight by one man alone, to ensure equality of strain; after which a man was allotted to each five screws. At the blow of a hammer each man gave a quarter turn to each of his five screws. The raising was two feet lift, and the jack-screws were fleeted three times. A spare screw was applied to the end of the timber, and the working screw relieved, blocking inserted, and then the shortened screw replaced.

A pile of blocking was laid in the cellar and other blocking built on the ground outside and levelled up with cross wedges, and two skids 12 inches square by 600 feet long were laid on the blocking. The cradle was then dropped upon the skids. The upper skid surface and the under side of the cradle were coated with soap. The skids were irregularly placed to suit the convenience of ground or direction, only it was necessary that the distance apart should be such that the chain attachment should work between them.

A long chain sling ($\frac{3}{4}$ in. or $\frac{7}{8}$ in.) was attached to the last or back timber, so that a pull was placed on all the braces, and the cradle was firmly clamped together. The bight of the chain came under the cradle and was brought to the front, and was there hooked into a tackle consisting of a pair of three-fold blocks with 8-inch manilla rope. The second block was hooked to a cross timber which formed a cross-head to the skids, and prevented them being drawn on end. The hauling part of the

rope led off to the crab which had a 12-feet bar, to which were attached two horses. The usual spuds held the crab.

The actual moving was at the rate of 2 feet per minute. The whole moving did not occupy two days, but some delay occurred in taking up the stone walls of the old cellar and building the new cellar walls with the material. The course, or path of the moving, was by no means straight; other foundations and irregularities of ground interfered, and an S path of 50 feet or more deviation was followed. The final position of the house, as left after removal *by the crab*, was within one-fourth of an inch of the exact place it should occupy, and this deviation was easily rectified by a jack-screw. The dropping upon the new walls was the reverse of the lifting, except that the screws were applied inside the cellar instead of outside as before.

The great excellence of this operation was its mechanical roughness and simplicity. Everything was convenient, adapted for the requirement, and ready for use, and the work was done by a gang of seven drilled, practical labouring men.

A CONVENIENT APPARATUS FOR HOT FILTRATION.[1]

By H. Carrington Bolton, Ph.D.

EVERY working chemist has experienced the need of a convenient apparatus for hot filtration. Hot saturated saline solutions which crystallize on cooling in the filter or in the neck of the funnel, and viscid liquids possessing the necessary mobility only so long as a higher temperature than the average is maintained, render the employment of some form of apparatus for *hot* filtration indispensable. While much attention has been given of late to the construction of apparatus for *rapid* filtration, as the innumerable forms of water pumps and steam injectors abundantly show, little has been done towards improving the existing forms of apparatus for hot filtration or the contrivance of new ones.

Two kinds of apparatus have come under our observation. The first of these, invented by Dr. Hare, is the well-known funnel support usually constructed of tinned iron, with double walls and a conical aperture for inserting a glass funnel; the space between the walls being filled with water or other liquid, it is kept at a boiling heat by a lamp placed under a cavity shaped like an inverted funnel. A more compact form of the same apparatus was contrived by Plantamour, in which the metallic box is given the form of a cone, and heat is applied to a hollow cylindrical projection filled with the liquid employed, and communicating with the space between the double walls.

While this apparatus is well adapted to the use of pharmaceutists or for the purposes of the manufacturer, it is not suited to the wants of the analytical chemist. The first form occupies much space, and both forms must be had in great variety of sizes to fit funnels of various dimensions. A small funnel is nearly lost to view in a large jacket, and a large funnel is not heated by a small one. Then, again, only well-made funnels, whose sides are inclined at an angle of 60°, will fit the conical opening. Moreover, the fact that the apparatus is constructed of metal is in itself a disadvantage. Only extraordinary care will keep the metal clean and bright in the atmosphere of a laboratory. The disadvantage could be largely overcome by nickel-plating the metallic box, but we have not seen this luxury introduced. In the filtration of liquids giving rise to very acid fumes, the use of a metallic jacket is hardly admissible.

The second apparatus alluded to is that contrived by Dr. A. Horvath, and described in the "Annalen der Chemie und Pharmacie," vol. clxxi. p. 135, 1874. A tube of soft lead one centimetre thick is wound around a funnel in the form of a spiral, one end being connected by a tightly fitting cork with a flask placed at a convenient distance, and the other end of the leaden pipe communicating with a recipient for the escaping vapours. Steam being generated in the flask, it passes through the leaden tube and warms the funnel and contents. This contrivance may work well, but is not very convenient; the inventor strangely enough adds that by employing ether, alcohol, carbon bisulphide, benzol, or anilin, in place of water, filtration can be carried on at any desired temperature. The question naturally arises, why select liquids having such low boiling points as ether (35·7° C.) and carbon bisulphide (46·6° C.) to effect *hot* filtrations; surely the cases are rare where the temperature could not be moderated, if desired, by generating steam less rapidly. Then, too, the atmosphere of a laboratory, where a dozen or more solutions are warming by the uncondensed vapours of carbon bisulphide, would be anything but agreeable.

There seems to be room, then, for a simple, cleanly, portable, and inexpensive apparatus for keeping the contents of a funnel hot while filtering, and it is believed that these requirements are filled by the new apparatus described in this paper.

The materials are found in any ordinary laboratory. Select a small funnel with a long stem, and a larger funnel with a wider throat, and cut the stem of the larger funnel short; slip a piece of india-rubber tubing of the required size over the stem of the smaller funnel, and then insert it in the larger one so that it fits water-tight. The inner funnel should project about half a centimetre above the edge of the outer, and as much below the stem of the latter as it admits. We have found the three sizes named below sufficient for all operations of analytical chemistry.

Dimensions given in centimetres; the first figures give the greatest diameter of the funnel, and the second its length including stem:—

	Outer Funnel.	Inner Funnel.
No. 1. . . .	7 × 6½ . . .	4 × 10
„ 2. . . .	10½ × 9½ . . .	6½ × 12½
„ 3. . . .	13½ × 13 . . .	10 × 17

Steam generated in a flask of about one litre capacity, and conducted by means of a glass tube into water filling the space between the two funnels, warms the filter on the inner funnel with its contents. In one experiment the water in the outer funnel marked a temperature of 97° C. and the liquid in the inner one 76° C. The temperature in the inner funnel may be greatly increased by covering it with a convex glass, or by employing a saline solution in the outer funnel.

As a matter of course, water condenses in the outer funnel, and must be removed from time to time. In the case of funnels No. 2 it accumulates at the rate of 30 to 35 c.c. in half an hour when boiling vigorously. This seems at first sight to be an objection, but the superfluous water can be so readily removed with a pipette or a siphon that it does not have much force. Or the accumulating water may be drawn back into the steam generator through diminished pressure by simply removing the lamp beneath the flask. In this case, the end of the tube should plunge but little below the surface of the water in the outer funnel, else the latter will be completely emptied.

Actually the operator is not at all annoyed by the necessity of attending to this point, for the filtration requires his constant presence. Should the outer funnel be filled with distilled water in the outset, an overflow would not prove serious; since the inner funnel stands higher than the outer, any disturbance of the precipitate by accumulating water is out of the question.

The great compactness and cleanliness of this apparatus make it available in quantitative analysis, and we have used it for some time with great satisfaction. After washing a precipitate on the filter it may be dried very speedily by simply continuing the heat; the dried filter removes easily, and so the two funnels once arranged need not be disconnected.

Other advantages will occur to those using the apparatus, such as the transparency of the outer vessel, the total absence of metal, and the increased rate of filtration consequent upon the higher temperature. The double funnel may be connected with a Bunsen water pump or other apparatus for rapid filtration.

In washing precipitates with hot water we have also found it feasible to direct the steam from a small generator directly into the filter itself; if care be taken to moderate the pressure, the precipitate is washed with hot distilled water without danger of loss by spattering, and this works almost automatically.

[1] Read before the New York Academy of Sciences, May 10, 1875 (from the "American Chemist").

RAILROAD TRAIN TIMER.

AN ingenious invention has lately been successfully tested on the Vandalia Railroad, Ind., which records the motion of railway cars. There is a locked iron box attached to one side of the car, and containing a clock. The mechanism of the latter causes a small drum, on which is wound a sheet of paper, to travel at a constant rate. With the axle, by means of rods and gearing, a pencil touching this paper is connected. As the pencil is moved slowly across the paper by its mechanism governed by the axle, and as the paper is slowly moved forward, the pencil point inscribes a diagonal line back and forth. The paper is ruled in very small sections, every

fourth line being dotted and representing one mile; so that supposing the car goes a mile in four minutes, the line will cross just four sections diagonally from one dotted line to the next one. If the car stops, the line crosses the paper directly and shows the number of minutes that the train is at rest.

The names of the stations are written at the proper places on the paper, and thus the exact rate of speed made at any point on the line can be subsequently noted. The apparatus thus affords an excellent check on the train officials, as, if the train be run ahead or behind time, the fact is sure to be detected.—*Scientific American.*

TWO HUNDRED AND FIFTY TONS OF BRICK WALL CARRIED EIGHTEEN INCHES WITHOUT INJURY.

ABOUT a month ago the Society St. Vincent de Paul determined to build on the vacant lots in the rear of their Twenty-third Street building. A survey of the land being made, it was discovered that the wall of the five-story brick livery stable adjoining encroached eighteen inches on their property. The owner was notified to remove the wall to the eastward, and Weeks and Brothers, builders, were authorized to tear it down and rebuild. Mr. Weeks did not like to pull down the wall, and proposed to move it bodily. The plan was ratified by several contractors, while others declared it could not be safely or successfully carried out.

Nowhere could be found in the history of building or house-moving an instance where a brick wall had been detached from a building and moved. The wall was thirty years old, and built of second-hand brick: 70 feet high, about the same length, 16 inches wide at the base, and about 12 inches at the top. Its weight was 250 tons. Ten yellow-pine needles, 12 by 12 inches, planed on the upper surface, were let in horizontally under the wall, at equal distances, just above the foundation, and at right angles to its face. The upper surface of each needle was profusely greased, and a smaller needle with its planed surface down, inserted along each larger one. Spur-braces fixed at the foot in these upper timbers held the wall plumb. The jack-screws, working horizontally, were set at the ends of the ten upper needles. This being done, an eighteen-inch slice was taken off vertically from the stable building just inside the wall. At 7 o'clock yesterday morning a man at each jack-screw began to work it, and the wall moved an inch safely. At this time one of the ten men did not work his jack as fast as the rest. The overseers were a little nervous at this, but the wall carried the lazy needle along with the rest. By 10 o'clock the 4,900 square feet of wall were pushed up tight against the open side of the stable, and the whole was perfectly plumb and unshaken. The men in th stables pursued their usual avocations during this performance.—*Extracted from the N. Y. World, Aug. 24th*, 1875.

IMPROVED WOOD-CARVING MACHINE.

WE illustrate herewith a new apparatus designed to perform all kinds of carving, from the coarsest scroll work or similar decoration used upon furniture, down to the pictorial engraving of wood blocks. The principal features of the invention are its simplicity and the ease with which it may be operated, requiring no skilled attention nor especial care other than that involved in the very plain proceeding of following the outlines of a given pattern with a pointer moved by hand. The machine, in construction, is nearly identical with the pantagraph, an instrument used by draftsmen for duplicating drawings on an enlarged or reduced scale, the carving cutters being substituted for the pencil used in that apparatus. A is the principal rod or shaft upon which the working part of the device is supported. Its inner end is attached to a sleeve which surrounds the vertical driving shaft B, which serves as a centre for the circle, an arc of which is described by the outer extremity of the rod, which is mounted on slides or rollers which traverse a curved track upon the table. Pivoted, as shown, to collars which slide freely upon the rod A, and which may be adjusted thereon and clamped in position by set screws, are bars, C and D, of the pantagraph frame. Said bars are connected by two other pivoted bars, E and F, which complete the square. The bar, C, carries the pattern tracer G, and the extremity of said bar serves as a handle for the workman to guide the tracer into the various curves and indentations of the pattern. Adjustably mounted upon bar D is a vertical shaft which carries the cutting tool H. Said shaft is driven by a belt from the pulley I, fixed at the central portion of the bar D, which, in turn, is actuated by another belt from the pulley located on the summit of the vertical shaft B. Shaft B is belted to the driving pulley shown under the table.

It will be obvious that any motion given to the tracer G will be at once followed by the cutting tool H, so that, for example, if the tracer be moved along the edges of a certain curve, the cutter will follow a like path. The latter, however, will be reduced in size, though in exact proportion, on account of the cutter being located nearer the centre of the circle, of which the bar A is the radius, than the tracer. Since the sleeves to which the bars C and D are pivoted are adjustable, it is clear that, the nearer the cutter is carried toward the shaft B, the smaller will be the path it describes, corresponding to that moved over by the tracer; and therefore the object, the outlines of which are followed by the latter, may thus be reduced to any less scale desired by suitable movements of the sleeve of the bar D, in or out on the rod A.

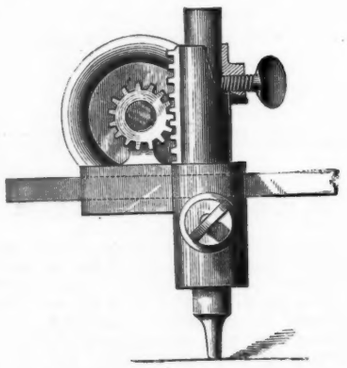


Fig. 2.

In the engraving, the machine is represented as carving the scroll work upon a pianoforte leg, which is mounted on centres so that the surfaces to be operated upon may be brought uppermost in succession. The work is always reduced in scale from three-fourths downward, so as to secure greater ease and accuracy in operation; and therefore the pattern, which is shown secured beneath the tracer G, is considerably larger than the article itself, which is fastened beneath the cutter.

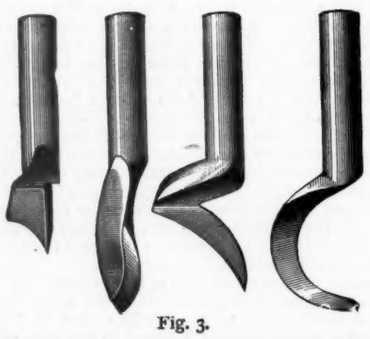
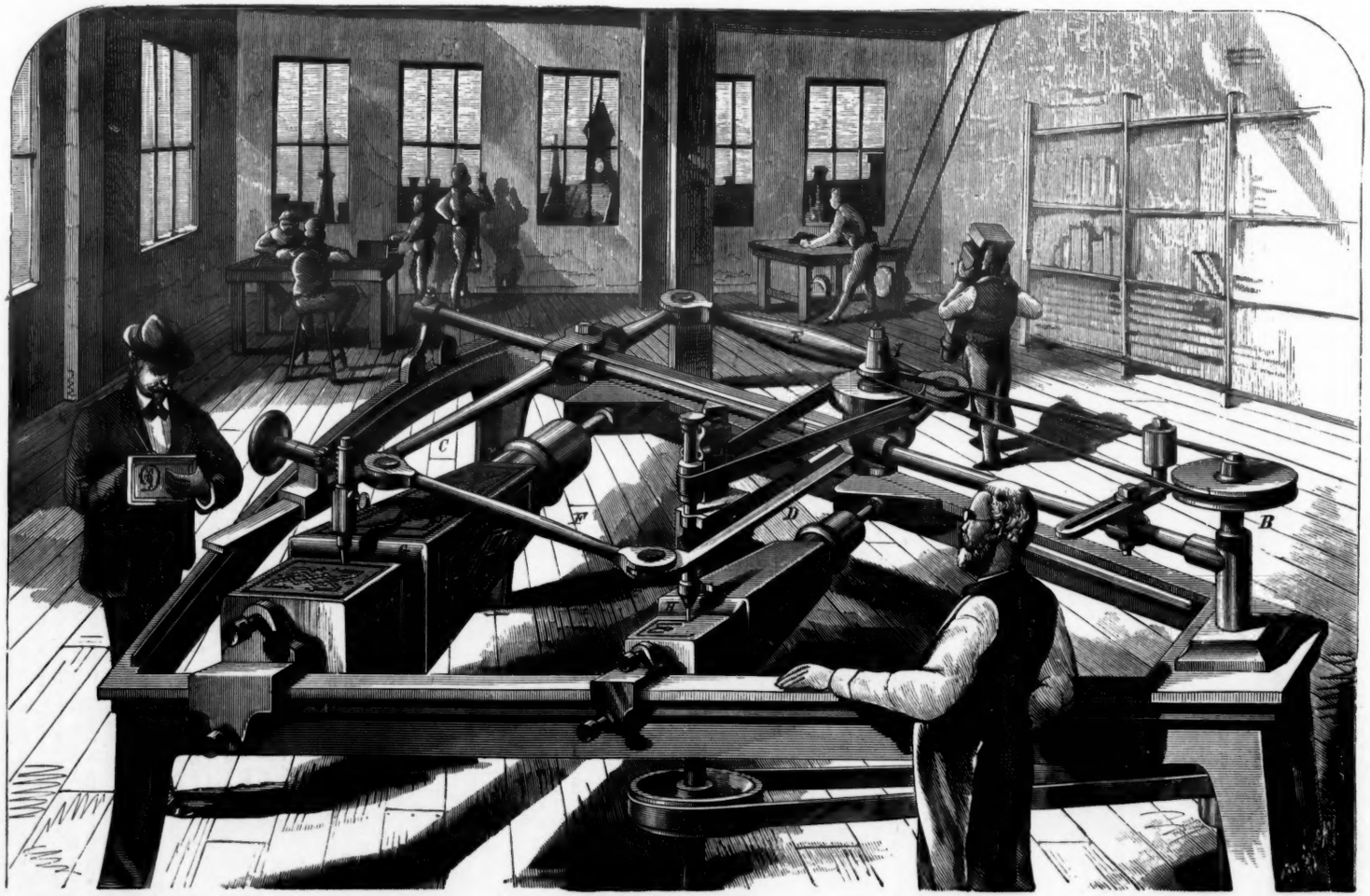


Fig. 3.

Thus far we have referred principally to the motions of the tracer and cutter in a horizontal plane. In order, however, to cause the tool to form the raised or indented portions of the work, it is necessary that there should be free movement in a vertical plane, so that, by continuous pressure on the tracer, the cutter may cut downward or be raised to leave certain portions in relief. The bar E, it will be noticed, is very much heavier in construction than bar F. It thus serves as a counterpoise, and balances the frame on centres on the sleeves on bars C and D which surround rod A. The motion of the frame, therefore, is



IMPROVED WOOD-CARVING MACHINE.

universal; and at the same time the parts are perfectly balanced in every position, reducing the manual labour of moving it to a minimum. This is probably the most important improvement in the invention, and gives a large advantage over the ordinary routing machine, the motion of the cutter of which is confined to one horizontal plane.

Connected with the upper part of the tracer G is a small rack, with which engages a pinion operated by a hand wheel. This device is shown more clearly in fig. 2. Its object is to control the vertical action of the cutter, so that, if desired, it can be prevented from making as deep an indentation as called for by the pattern, or just the reverse. In fig. 3 several forms of the cutters used are shown.

The capacity of the machine is large, since the table may be built on a more extended arc, thus admitting of an area to be worked over as great as is afforded beneath the cutter, allowing, of course, room for the pattern. The invention is light in all its portions, and easily constructed. It will prove, we think, a valuable aid to workers in wood of all classes.—*Scientific American.*

ROYER DE LA BASTIE'S TOUGHENED GLASS.

By Henry Pocklington.[1]

ROYER DE LA BASTIE'S "tempered," "toughened," or "hardened" glass (for we have a choice of terms) is simply glass that has been heated to softness and plunged into an oil bath of a "certain temperature," and thereby suddenly cooled. The process is extremely simple, but for its performance on a manufacturing scale will require, the patentee claims, the machinery described in his specification. This document has attained the rare honour of a second edition, showing that considerable public interest has been taken in the invention; and having regard to this, and the wide publicity given to the general features of the invention, it is not, I think, necessary to occupy the time of the Conference with details respecting either the process or the machinery for its application. The essentials are, heating the glass to a high temperature and plunging it into a bath of a certain temperature and composed of certain materials. The specification does not state the temperature to which the glass must be heated, except somewhat vaguely, and leaves us in entire doubt as to the temperature of the bath. The materials claimed in the specification of which the bath is to be, or may be, composed are oils, fats, resins and tars, and other like substances boiling at a higher degree than water. From this it has been inferred that the process of hardening is a chemical one, and that "the glass takes up some of the constituents of the bath;" but I do not see that this conclusion is supported by the specification in which the patentee expressly, and I think in part correctly, explains the process on the hypothesis that the molecules of the glass are compressed in the act of sudden cooling, and his use of oleaginous substances has been chosen on account of their high boiling points, without reference to any chemical property or affinity they may have.

My work on the glass may fall under two heads—I first endeavoured to ascertain its structure by means of polarized light, and then experimented upon its manufacture on a laboratory scale.

As regards the first of these points, the structure of the glass, the thought immediately presented itself that this was a particular case of Rupert's drops, or, in other words, of molecular instability in temporary restraint, and this view is much supported by the phenomena attendant upon the disruption of the glass, which, as you all know, flies into a thousand pieces when its continuity is broken in the least. But this view is repelled with some indignation by the apologists of the process, and does not appear to be wholly consistent with the phenomena, unless, as is probable, De Luynes' theory of the nature of Rupert's drops be the correct one, and we look upon the toughened glass as an extreme modification of them.

If we examine a strip of glass prepared strictly in accordance with Bastie's process, between Nicol prisms, we shall find that it behaves in all essential respects as unannealed glass, excepting that the "permanent bands" seen when the prisms are not crossed do not occur so irregularly as in unannealed glass, and that the "brushes" are remarkably strongly defined. In other words, the toughened glass manifests the phenomena of a well-formed and evenly balanced crystal in a more marked degree than ordinary unannealed glass. This is brought into striking prominence if we contrast with Bastie's glass a strip of glass of similar dimensions prepared by cooling between a thick and a thin metal plate, or between a thick metal plate and the bottom of a thin vessel containing water. In the latter case we shall notice that the "isochromatic" lines or "permanent bands" are irregularly localized and very differently defined in various portions of the plate. In these experiments we transmit the light from back to front of a thin strip, and consequently have to do with but a thin stratum of the glass, and can gain little knowledge of the state of the internal layer save as that may differ over superficial extension, and we learn so little hereby that I have not thought it desirable to trouble you with details respecting the phenomena observed. We gain much better results when we send the polarized light through a strip parallel with its face; we can thus explore the whole interior without serious interference by the superficial layers. The method pursued is this. I take a strip of toughened glass about three quarters of an inch wide and of any convenient length. The opposing surfaces through which the light has to be transmitted must be ground plane and parallel. If not, the one polished surface should be cemented to a glass slide with Canada balsam, the slip of toughened glass standing upright, and the other surface covered with a piece of microscopical thin glass cemented on with balsam. The front and back of the glass may be blackened, or screened to exclude extraneous light, and the carrier should also be blackened so that no light shall enter the analysing prism save such as has passed through the strip of toughened glass. If this be now placed on the stage of the polariscope we shall be able to examine it with ease. The phenomena are briefly these:—If we use the monochromatic sodium light, we observe that the centre of that strip is dark when the prisms are crossed, and that it is surrounded by alternating lines of light and dark gradually becoming narrower as they approach the surface. By polychromatic light, daylight, for example, the centres of the strips I have examined have usually been red or green (crossed or not crossed prisms), the lines in this case resembling the chromatic rings of Newton's series seen in transverse sections of crystals in the field of the polariscope. These lines are really portions of extremely elongated ellipses, as may be seen if they be traced to the end of the strip and round it. The centre is evenly coloured in well-tempered specimens, and the "lines" remain sensibly parallel for considerable distances, but in ill-prepared specimens, as prepared by the method indicated, the colour of the centre varies much, the lines are less well defined, often not so numerous on one side of the central (eccentric then) portion as on the other, and are not sensibly parallel for any appreciable distance; in fact, it is quite easy to tell by polariscope analysis whether the glass is really well toughened or whether only "unannealed." Now, in the difference between these kinds of glass may, I think, be found the secret of the phenomenon of "hardening." We have, in a few words, in the case of tempered glass, a strip of glass consisting of exconcentric layers of very different density, in a state of different stress, encircling a central portion which is almost sensibly common glass; it may, in fact, be regarded as a trussed girder composed of thin plates, considerably elastic, but with weak trusses. When these give way the girder flies asunder, but till they do it is remarkable for its strength. This, according to De Luynes, is essentially the structure of Rupert's drops. But there appears to me to be this difference between them. According to De Luynes the interior layers of Rupert's drops are the contracted layers, the exterior the dilated; whereas in toughened glass I have, I think, abundant reason for supposing that the contrary is the case. The polariscope phenomena indicate increasing compression towards the exterior, microscopical examination of fractured portions, especially when ill-tempered, shows curves indicating compression by the exterior and the disruption of such specimens frequently assumes a character only explicable on the theory, which is further supported by Bauer's determination of the specific gravity of specimens prepared by him (in paraffin) where the specific gravity increased from 2·424 before hardening to 2·438 after, and from 2·460 to 2·468 in another specimen. I may remind the Conference that De Luynes has recently shown that Rupert's drops of fused boracic acid are distinctly foliate in structure, and has quite confirmed his previous opinion that such was the character of the glass Rupert's drops, and that their stability, when entire and complete, and disintegration when injured, is due to the gathering up and centralization of the various lines of stress and strain in a portion of the drop near the neck (not in the thin part of the tail, as generally supposed).

The foliate character of Bastie's glass is quite supported by the appearance under dissection, but I have made no personal observation on this point which I can consider sufficiently valuable to be worth communication in any detail.

[1] A paper read at the British Pharmaceutical Conference.

To sum up this part of the subject, we find that Bastie's glass is glass in a state of mechanical compression; that it may be regarded as a stressed or trussed girder, that it is the outside which compresses the inside, and that the outside is much harder than the inside; and, finally, that it differs from unannealed glass and from Rupert's drops in the even distribution of its lines of stress, and in their regular and concentric compression of the interior.

My account of the result of my experiments under the second point, the manufacture of the glass, must not occupy much time. I have simply attempted to discover the essentials necessary to success. I very soon found that it is absolutely necessary to raise the glass to a high temperature, that it must be made quite soft, but that a wide range of temperature may be allowed in the bath. I found, for instance, that good specimens could be prepared with oil at 50° C. when the glass was thin (common window glass) and very hot, and I found little difference between one kind of oil and another. I then turned my attention to other fluids than oil (excluding fats and tars) and found that neither water nor aqueous solutions, alcohol or similar mobile fluids, will at all answer, whatever be the temperature to which they be raised; but I found—and this may be of importance if the manufacture of glass prove to be profitable—that very good tempering can be done without the use of a bath at all. A brass plate one-eighth of an inch thick, supported on brass legs, is heated to 100° C. or thereabouts, the hot glass placed upon it and immediately covered with a similar piece of metal. This glass is not so hard as the Bastie's, but, on the other hand, it does not fly into such minute fragments when disintegrated, and it is vastly harder than common glass. Still better results are obtained by placing the glass between thin metal vessels containing heated oil or even water. From this I draw the conclusion that the essential to the process is this, that the glass shall be very rapidly cooled for a *very* short space of time, and that the cooling shall thenceforward be gradual. If we watch the process in oil placed in a glass vessel, we shall see that, although rapid convection currents set in and cooler masses of oil are rapidly brought into contact with the glass, yet these are incomparably less rapid and far more regular than what occur when water is employed. In this case, the water in immediate contact with the glass is raised into steam absorbing an enormous amount of heat, and escapes rapidly, bringing fresh and irregular portions of cold water into contact, when the same again occurs. The comparatively low specific heat of oil is also probably an important factor in the case.

It would be out of place here to offer any remarks on the probability of the practical advantages of Bastie's discovery, and I will conclude by expressing my regret that I have not been able to place the subject before the Conference with the completeness I wish. I must also express my regret that the results of De Luynes' investigation of the subject have not yet been made public, and that I am in entire ignorance of either his methods of research or the results he has gained.

MORRIS'S PATENT CHARTOMETER.

MEASURING INSTRUMENT.

MEASURING INSTRUMENTS.

THE chartometer, of which our illustration gives a very good idea, must be a most useful instrument to every one having occasion to use maps and charts, especially the large class of travellers and tourists who like to measure the distance over which they have travelled; it lends itself to the measurement of the most eccentric curves and zigzags with as much facility as the measuring of a straight line. The instrument consists of a case about the size of a large watch-case; a point projects, on which is a small steel wheel; this wheel is made to traverse the distance to be measured, and by means of suitable wheels causes the hand to register it on the dial. The operation is a most simple and expeditious one. The instrument is provided with a set of movable dials, which are easily placed in positions adapted for the scales of all ordnance maps; also dials for "reduced ordnance" (one-half, one-third, &c., of the scale of the "one-inch ordnance"), and dials to suit the usual scales of maps of towns, counties, &c., and of maps for tourists. By slight calculation many maps of unusual scales may be measured; for instance, to measure a map of the scale of 22 miles to an inch, use the dial "11 miles to an inch," and double the result; or, 3 inches to a mile, use the "6 inches to a mile," and double the result. It may sometimes be advantageous, as in the scale of 2 inches to a mile, to have the result in furlongs; 2 inches to a mile is 4 furlongs to an inch, then use the dial "4 miles to an inch," and read the result in furlongs instead of miles.

It will be obvious that it makes no difference to the dial whether the miles be statute or nautical; for instance, the dial "1 mile to an inch" serves equally well for the scale 1 inch to a geographic mile, or minute of mid-latitude, expressed nautically, "m = 1·0;" and the scales 2, 4, 5, and 10 miles to an inch, are respectively the same as m = 0·5, 0·25, 0·2, and 0·1.

Should maps of unusual or irregular scales be met with, they may be measured in three ways:—Firstly, as explained before, by using a dial in which the result would be correct if doubled, or halved, &c., as the case may be. Secondly, when the irregularity of the scale renders that plan laborious, suppose an extraordinary scale of, say, $5\frac{1}{2}$ miles to an inch; then, by first method, it could be measured by using the "7 miles to an inch" dial, and taking three quarters of the result; or it may be measured without calculation by using any dial, and re-measuring or retracing that distance on the scale printed on the map, and taking the result on that scale. Thirdly, by drawing a dial to suit a peculiar scale. Those who use Admiralty Charts, in which chiefly irregular scales are numerous, and who are accustomed to the use of a pair of compasses, would experience no difficulty in forming their own special dials, by

cutting out a card, or even using the clean back of one of the dials supplied, and by marking the position of the hand after a convenient distance had been travelled by the instrument upon the scale printed upon the chart, and then forming and figuring proper divisions upon the dial; it will also be clear that to suit a scale, for "miles" on the dial, any other standard of lineal measurement may be substituted; for instance, the dial "1 mile to an inch" may be used for 1 furlong, 1 yard, or 1 foot to the inch, by simply reading off the result in any of those terms instead of miles; and the dials, 2, 3, 4, 5, 6, 7, or 10 miles to an inch become $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, or $\frac{1}{10}$th of an inch to the foot, by reading feet instead of miles.

It will thus be seen that the instrument is adapted to the measurement and laying out of plans and drawings to scale. By using the dial indicating 1 mile to an inch, it becomes for purposes of ordinary measurement an inch rule, registering the inches by tens.

Mr. Morris, the inventor, has also patented a measuring instrument on the same principle; the arrangement will be readily understood on reference to the illustration, which is full sized. The minute hand indicates inches and fractions of an inch, the hour-hand feet, and the second-hand tens of feet—thus the drawing is represented as registering 41 feet $9\frac{1}{4}$ inches. It cannot fail in almost all cases to supersede the ordinary measuring tape, which takes two persons to use it, and speedily gets so dirty that the figures can with great difficulty be read, objections which are obviated in the new instrument, the simple operation of running it along the work to be measured, registering the length on the dial, and the glass face keeping the dial always clean and the figures distinct.

Altogether the instrument bids fair to become one of those little handy aids to practical men that, once taken into use, cannot be done without. Both instruments have just been awarded a silver medal at the Manchester Exhibition (Pomona, 1875).

Engineering, Building, &c.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

§ 1. *Engineering.*

Curve Scale.—This useful little instrument, the invention of a German engineer, Herr EICHENHAUER, of Essen, is figured in the undermentioned journal. It is a flat piece of wood, or metal, 4 in. long, 2 in. wide at top and 3 at bottom, with two longitudinal slits, the sides of which are graduated to give the logarithmic radii of arcs, of which the corresponding widths of the slits are the chords. By laying the instrument over a map or plan, the radius and centre of any curve thereon can be ascertained without resorting to construction. In like manner, in railway work the radii of curves connecting two or more points can be at once determined. *Neue Deutsche Gewerbe-Zeitung, No.* 18, 1875.

Tailors' Cutting-out Machine. — ROLLAND, tailor, 24, Rue de Croncels, Troyes, has patented a machine, by which garments of all sorts are cut out very accurately and expeditiously. *Neue Deutsche Gewerbe-Zeitung, No.* 19, 1875.

Portable Horizontal Engines.—In No. 18 of the "Neue Deutsche Gewerbe-Zeitung" is a representation of a portable horizontal engine (not on wheels) with vertical (Field) boiler, constructed by KÖBNER and KUNTZ of Breslau. The design appears to be in every respect inferior to that of the vertical engines of the same type lately exhibited by several eminent English makers, such as the portable vertical engine shown at Taunton a short time since by Davy, Paxman, and Co., of Colchester.

Concrete Blocks as Substitutes for Sleepers.—M. A. COURREUX, one of the principal contractors for the Suez Canal works, and the inventor of a system of dredging which has been much employed in the improvement of the Danube below Vienna, has carried out a series of experiments with blocks of concrete in iron cases, as substitutes for wooden sleepers on lines of railway. The results are stated to be in every way satisfactory. The blocks are nearly hemispherical, following the slope of the ground, with their convex sides uppermost, and consist each of a case of iron plate, strengthened internally by three light stay rods, and filled with concrete composed of the best hydraulic lime mixed with sand and gravel in the usual proportions. Passing through the concrete are two upright iron rods, the lower ends of which are hooked to the transverse stay rods, whilst the upper are furnished with screw heads passing through a flat iron plate, resting on the top of the concrete. A sheet of asphalte is interposed between the concrete and the flat iron plate to deaden shocks and prevent vibration.

The rail rests on the iron plate, and is kept in its place by the pressure of the nuts of the upright rods which are screwed down against its foot on either side. Additional rigidity is given by strong iron cross bars placed at intervals against the feet of the rails, which maintain the gauge and gradient of the rails. For rails 6 metres long five such blocks are used, each supporting 40 centm. (16 in.) of rail. The portion of each rail thus supported is therefore $5 \times 0{\cdot}40$ m. $= 2$ m. With oaken sleepers, 7 per rail, the length supported is $7 \times 0{\cdot}18$ m. $= 1{\cdot}26$ m. showing an advantage of 0·74 m. in favour of the blocks.

Two blocks of concrete, with the iron cross-bar, contain 17 kilogs. of iron, which at 45 fr. per 100 kilogs. is	7·65 fr.
Add: 100 cubic metres of concrete, at 33 fr. 50 c. per metre	3·35 „
Labour	11·00 „
Total	22·00 fr.

This is equivalent to 9 fr. 16 c. per running metre of permanent way. With oaken sleepers costing 8 fr. each, the average would be 9 fr. 33 c. per running metre. The oak wood is often green and sappy, and quickly decays, especially in inferior ballast. The concrete blocks are unchangeable and will last for an indefinite time. The cost of removing the sleepers and the hindrance to traffic thereby occasioned are thus avoided. *Revue Indust., 15th Sept.*, 1875.

New Substitute for Lubricants. — M. JACOB has lately patented a composition of: 1. Plumbago 35 parts, talc or asbestos 25, sulphur 20, and wax or paraffine 20; or, 2. Plumbago 30 parts, bone glue 15, water 32, sulphur 12, wax or paraffine 11. Laid over bearing surfaces the composition acts as a substitute for lubricants of all kinds. Instances are stated to be known where machinery thus provided has been running for fifteen months without requiring lubrication. *Moniteur Indust. Belge, 20th Sept.*, 1875.

Sawing by Electricity.—Mr. G. ROBINSON has patented a new process for sawing wood. The process consists in substituting a platinum wire for the saw. The wire is heated to a white heat by the passage of an electric current. The wire, to which a forward and backward movement is given, cuts across the hardest woods with inconceivable ease. Constantly maintained at a white heat by the electric current, it advances in the wood by carbonizing the surface which it touches, but this carbonization is entirely superficial, and has no bad effect. *Telegraphic Journal, 15th September*, 1875.

New Cement for Joints of Iron Pipes, &c.—LEMOUCHE uses the following composition:—

Iron turnings	6·173 kilogs.
Red lead	0·617 „
Pipeclay	3·086 „
Sal ammoniac	0·124 „
	10·000 „

The materials are placed in a tub and well mixed with 1·75 litres of water. The proportions of the several substances are varied according to the character of the cement required. *Moniteur Indust. Belge, 1 Oct.*, 1875.

Curve Measurer.—A simple and useful little instrument for measuring curved lines on maps and plans is manufactured by BILSTEIN, 31, Rheinstrasse, Darmstadt, in the shape of a double-hafted tracing point, fitted with a miniature measuring-wheel. The price, in plated zinc, is 3 marks (shillings). *Neue Deutsche Gewerbe-Zeitung, No.* 19, 1875.

Tabarant's Protractor.—The attention of the Société d'Encouragement has lately been called to an invention designed by M. TABARANT to facilitate the plotting of surveys made with the dialing or other compass. It consists of two distinct instruments:—1. A rectangular wooden frame, with articulated joints, somewhat resembling a pentagraph, one side of which is clamped or weighted to agree with the meridian line, true or magnetic, of the plan. 2. A semicircular protractor with movable arm and vernier.

In use, the protractor is set to the required angle, and laid

with its straight edge against the side of the rectangle which is opposite to the fixed side, and consequently parallel to the meridian line of the plan. The rectangle is then worked as a parallel ruler, and the bearing can be laid off at any desired point without the necessity of centering the protractor over such point.

The straight edge of the protractor is fitted with a graduated complementary arc of a radius equal to the diameter of the protractor. By setting this arc to an angle corresponding to the magnetic declination, and laying the radius of the arc—instead of the diameter of the protractor—against the side of the rectangle, magnetic bearings can be laid down, to the *true* north, without previous reduction, in the same way as before. *Technologiste, Sept.*, 1875; *from Bulletin de la Société d'Encouragement, March*, 1875.

Machine for Crushing Olives.—The "Gaceta Industriel" of Madrid states that a Spanish officer, Colonel Villaverde, has invented a machine for pressing olives, which is likely to bring about a complete revolution in olive culture. It is very simple, can be worked by hand, is easy to set up and manage, and costs only 7,000 reals (£80). With it one man can stone and press 50 to 75 *fanegas* (bushels) of fruit in a day. We call attention to it as likely to prove of service in some of our colonies, where olive-growing is now being attempted. No details are given, but full particulars can be obtained from the inventor, at his residence, 29, Calle de Enrique de las Marinas, Cadiz.

New Meteorological Instruments.—At the recent Geographical Exposition at Paris, a very beautiful little instrument, of extremely moderate price, was exhibited by Professor F. RISSELBERGHE, of the Belgian Naval School at Ostend. It is an improved form of the *meteorograph* exhibited at the International Exposition of 1867 by the distinguished Italian astronomer, Father Secchi. This instrument, which was about 15 ft. high, was designed to record, by the graphic method, and automatically, with the aid of several separate tracing points, the readings of the barometer and psychrometer, the time and amount of rainfall, and the force and direction of the wind. In Professor Risselberghe's instrument, which occupies a space of 18 inches every way only, the same results are obtained with a single tracing point. The maker is M. Schubert, instrument maker to the University of Ghent. *Moniteur Indust. Belge, 20th Sept.* 1875.

At the Congress of Italian Architects and Engineers, held at Florence in September last, the "Fluvial-Hydraulic" Section, presided over by the Commendatore Lombardini, examined and accorded special commendation to two new instruments—a *pluviometrograph* (for rainfall), and a *hydraulimetrograph* (for watercourses), both the invention of an Italian engineer, Signor Felice Matteucci. *L'Economista* (*Florence and Milan*), *26th Sept.* 1875.

§ 2. *Building, Decoration, &c.*

Improved Wall Tablets.—F. HOFFMANN, of Leipzig, has discovered a process by which any description of slate may be adapted for wall tablets in school-rooms, lecture-halls, &c. Slate so prepared takes a sharp, clear impression both with chalk and slate-pencil. The impressions are easily effaced by washing in the ordinary way. Unlike common writing slate, the surface does not shine when wetted, but remains dull, and shows chalk or pencil-marks as distinctly as when dry. The process is not described, nor is the cost stated. *Stummer's Ingénieur, 24th Sept.*, 1875.

Cement Water-Pipes.—HERR FUHRENWALD, in a communication to the Berliner Bezirks-Verein, states that the pipes first employed gave very unsatisfactory results, cracking readily with every change of temperature; but they have since been much improved. A sort of concrete is now used out of which the pipes are moulded on an iron core, and hardened by slow firing for fourteen days. The shape is the same as that of ordinary earthenware pipes, but with raised external mouldings. Dyckerhoff and Sons, of Bieberich, on the Rhine, by whom these pipes were first introduced, make them without mouldings. They support a pressure of ten atmospheres. They are chiefly used for mains, and are free from the defect, common in earthenware pipes, of collecting impurities at the joints. The pipes are in lengths of 1·9 metre (about 6 ft.). Larger sizes are rather cheaper, and the smaller about the same price as earthenware pipes. *Stummer's Ingénieur, 20th Aug.* 1875, *from Zeitschrift des Deutsches Ing. Verein.*

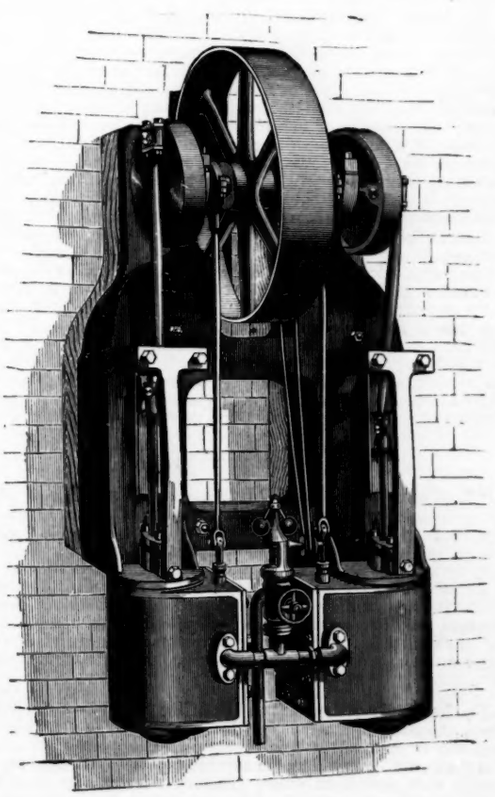
[Some account of the manufacture of "cement wares" at Dyckerhoff's Works at Bieberich will be found in the "Builder" of 18th Sept., 1875. H. M. C.]

Ebony Stain for Wood.—LAUBER dissolves extract of logwood in boiling water until the solution indicates 0° Baumé. 5 litres of the solution is then mixed with 2½ litres of pyroligneous iron mordant of 10° and ½ litre of acetic acid of 2°. The mixture is heated for a quarter of an hour, and is then ready for use. *Deutsches Chem. Gesellschaft. viii.* 1875.

Utilization of Plaster Rubbish.—GAUDIN, 13, Rue de Vaugirard, Paris, patents a method of treating plaster rubbish with carbonate of soda, by which it is rendered fit for use over again. Old plaster, even after it has been reburned, sets too quickly for use. By calcining the rubbish and mixing it with some saline solution instead of pure water this is prevented. Alkaline solutions are best, and of these a solution of carbonate of soda in water is the cheapest. Plaster from old walls and ceilings when thus treated sets at the end of two or three hours, and has all the properties of fresh plaster. *Bulletin de la Soc. Chim. de Paris, xxiv.* 687, *5th Oct.*, 1875.

WALL STEAM ENGINES

SCHOCH and Co., of Vienna, construct these miniature engines, for industrial and domestic purposes, in three sizes—four horse-power, six horse-power, eight horse-power. Each engine is complete in every detail, has a pair of upright cylinders, and gear for belting, the whole securely fixed in an upright frame that can be screwed to the wall, in any convenient spot, in the fashion of a hall-clock. Pipes for



the supply and escape of the steam are led along or through the wall. In the four horse-power engine, a figure of which is annexed, the cylinders are each 102 millimetres (3·9 in.) in diameter, with a stroke of 203 millimetres (7·9 in.), and work up to 180 revolutions per minute. The driving wheel is 508 millimetres (20 in.) in diameter, and 114 millimetres (4·4 in. broad). *Stummer's Ingénieur, 17th Sept.*, 1875.

Chemistry applied to the Arts, Manufactures, &c.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

§ 1. *Acids, Alkalies, and Salts.*

BORACIC Acid.—Professor V. DE LUYNES has made a series of experiments with boracic acid, of which the following is a summary :—Melted boracic acid resembles glass in appearance, but has certain distinguishing characteristics. In a semi-fluid state it can be drawn out in threads like glass, but its ductility is that of silica rather than glass. In hardness it equals glass. It is scratched with difficulty by sand, sandstone, and emery, either dry or mixed with oil. For use, it must be subjected to the action of water. In this case the cutting occupies seven or eight times as long as glass under like conditions. Melted in a lump and placed in contact with water, it absorbs the latter slowly. In a powdered state it takes up water rapidly. As Ebellmann has shown, the hydrate of boracic acid is determined by a temperature of 100° C. Boracic acid, like glass, may be run down over metallic surfaces. Care is requisite that the glaze so produced may not be cracked by flexion. It may be manufactured in Rupert's drops, like glass. Under polarized light, a sheet of tempered boracic acid behaves like tempered glass, but, whereas the latter loses its character when re-tempered, boracic acid retains it with singular tenacity. *Moniteur Indust. Belge*, 1 *Oct.*, 1875.

Action of Bacteria on Nitrogen Compounds.—M. MEUSEL records a singular fact. Perfectly fresh water, containing no traces of ammonia or of nitrites, and no compound of nitrogen whatever (except a percentage of nitric acid), after standing for a time, gave indications of the presence of nitrites, evidently resulting from the decomposition of the nitric acid through the agency of the animalculæ known as *bacteria*, the presence of which in the water was shown by the microscope. When phenic, salicylic, or benzoic acid, or even alum or a concentrated solution of common salt was added, the reduction at once ceased. Repeated experiments confirmed the above view. M. Meusel deduces therefrom the following conclusions :—1. The presence of nitrites in water containing nitrates or organic matter, particularly sugar, starch, cellulose, &c., is due to *bacteria*. 2. These animalculæ serve as agents for the transmission of oxygen, even when existing in a state of chemical combination. It is probably on account of this faculty of consuming oxygen that their presence is so deleterious to man. 3. Nitrates are useful as manure, not only on account of the nitrogen they contain, but also of the oxygen, with the aid of which the bacteria destroy the organic matter. Here, then, is a new point of view from which the decomposition of vegetable matters must be regarded. *Comptes rendus, lxxxi.* 13, *27th Sept.* 1875.

§ 2. *Metallurgy.*

"Gallium."—a New Metal.—At the meeting of the French Academy of Science, on 20th September, a sealed packet deposited on 20th August was opened, announcing the discovery, by M. LECOQ DE BOIS-BAUDRAN, of Cognac, in blende from the mine of Pierrefitte in the valley of Argèles, Pyrenees, of a new elementary metal, closely allied to zinc and cadmium, which it is proposed to call "gallium." It has as yet been obtained only in the state of a hydrochlorate or a sulphate, but its characteristics are sufficiently distinctive to admit of no doubt of its existence. *Comptes Rendus, lxxxi.* 10, *20th Sept.* 1875.

To keep Sodium in a Metallic state.—BÖTTGER places the sodium in a capsule filled with alcohol, and leaves it until the surface of the spirit presents a clear metallic lustre. It is then quickly transferred to another capsule containing chemically pure petroleum ether. Thence it is transferred to a third, containing a saturated solution of naphthalin in petroleum ether, in which it will keep without undergoing the slightest change. *Technologiste, Sept.*, 1875.

Intense Black on Copper Alloys.—According to WEISKOPF, chloride of platinum, when exposed to the air, produces a very intense and permanent black on pinchbeck, brass, gun-metal, and other cuprous as well as argentiferous alloys. The best mode of applying it is to dip the tip of the finger in a solution of the chloride, and rub the surface to be blackened with it hard. The blackened surface is afterwards washed, and polished with chamois leather and oil. The high price of platinum chloride notwithstanding, the process may be regarded as economical, owing to its simplicity and the small quantity of the salt required. *Technologiste, Sept.*, 1875.

Metallic Lubricant.—O. TROSSIN, engine-builder, of Hamburg, suggests the use of some soft, easily fusible alloy, as a substitute for grease or other lubricants in machines running at very high speeds. The alloy recommended consists of 5 parts tin, 5 lead, 5 bismuth, 4 cadmium. It fuses at 65·5° C. (150° Fahr.) To obtain a higher fusion point, the proportion of lead may be increased. *Technologiste, Sept.* 1875, *from Dingler's Polytech. Journal.*

§ 3. *Dyeing, Calico Printing, Bleaching, Tanning, and Allied Subjects.*

Removal of Stains with Magnesia.—Carbonate of magnesia—magnesia that has been previously calcined is best—is dried in an oven and mixed with sufficient benzine to form a soft friable mass. In this state it is put into a wide-mouthed glass bottle, well stoppered, and kept for use. It is spread pretty thickly over the stains, and rubbed well to and fro with the tip of the finger. The small rolls of earthy matter so formed are brushed off, and more magnesia is laid on and left until the benzine has evaporated entirely. Materials that will bear washing are then cleaned with water ; on silks, alcohol or benzine should be used instead. The process may be applied to textile fabrics of every description, except those containing very much wool, to which the magnesia adheres very tenaciously. It may also be used for stains, old or new, on all sorts of fancy woods, ivory, parchment, &c., without risk of injury. Ordinary writing ink is not affected by it, but letterpress quickly dissolves, owing to the absorption of the fatty matter in the ink. *Revue Indust., 22nd Sept.* 1875, *from Moniteur de la Teinture.*

A New Pigment.—Mr. LUKE NATTRASS, of Nelson, New Zealand, has received a diploma of merit from the late International Exhibition, at Vienna, for a new indigenous vegetable pigment prepared by him from the hinau tree (*Elæocarpus hinau*). Competent judges pronounce the pigment to be as good if not better than sepia. It is manufactured at 6*d.* per oz., whereas the same weight of sepia costs 11*s.* The bark of another species of hinau (*E. Hookerianus*), of Auckland, contains 8·60 per cent. of tannin. *Journal of Applied Science.*

Poisonous Dyes.—It is suggested that the case of skin-poisoning at Stettin (reported in "Practical Magazine," Sept., 1875), which was attributed to the aniline dye of a hat-lining, may have been caused by the mercurial nitrate used in dressing the hare-skin of which the hat was made, and not by the dye at all. *Reimann's Farber-Zeitung, No.* 33, 1875.

Bleaching Paste in Paper Manufacture.—Referring to the bleaching paste prepared by M. COUSIN-BORDAT, of St. Denis, as a substitute for chlorine, which was noticed in the "Practical Magazine" for July, 1875, the under-mentioned journal observes that an impression prevails amongst paper-makers that it is dearer than the methods in ordinary use. This has arisen from the imperfect manner in which the first experiments were made. When the materials are brought to a suitable degree of communication so as to facilitate the action of the paste to the utmost, the effect will be very different.

Annexed are the results of some experiments in bleaching various materials with the paste :—

Material operated upon.	Duration of the process.	Per kilog. of bleached material.
	Hours.	Centimes.
Cotton was bleached in . .	6	at a cost of 20
Hemp and flax " . .	6 to 12	" 20 to 25
Jute or phormium " . .	12	" 20 to 25
Alfa (2 preparations) " . .	24	" 15 to 20
Cocoa-nut fibre (2 preparations) was bleached in	24	" 15 to 20
Straw was bleached for paper in	12	" 18 to 20
Wood " " .	12 to 15	" 18 to 20
Rags " " .	12 to 24	" 15 to 18
Spinners' waste jute " .	6	" 12 to 15
Spinners' waste hemp and flax was bleached for paper in .	6	" 12 to 15

There were differences of several hours in the duration of the process, together with slight differences in the cost, according to the *tone* produced. *Technologiste, Sept.*, 1875.

"Eau Nacrée" (Pearl Water), for Instantaneous Bleaching, is prepared by BOISSELIER in the following manner :—

In 2 kilogs. 500 grammes of water heated to 90° or 100° C. are introduced in succession—

Nacre	100 grammes.
Indigo	5 milligrammes.
Cochineal	5 „
Chloride of lime	10 grammes.
Crystallized soda	10 „
Potash	10 „

After boiling for half an hour the composition is ready for use. According to the inventor, the nacre acts as size, smoothing, glazing, and softening the fabric, so that hemp is rendered as soft as cashmere ; the indigo "blues," the cochineal brightens, the chloride of lime bleaches, the soda cleanses mechanically, and the potash removes the grease.

Linen is plunged in the mixture for the space of one to ten minutes, according to circumstances, and comes out perfectly bleached. Eau nacrée may be used in the same way for bleaching silk, wool, and new fabrics of all kinds. *Moniteur Indust. Belge, 1st Oct.*, 1875.

Spirit of Panama—a Substitute for Ox-gall. — LECLERC states that this preparation will serve for two purposes —1. To remove stains from all kinds of textile fabrics. 2. To renovate part-worn wearing apparel, &c. For removing stains, it is used pure ; for cleaning wearing apparel, diluted with five or six times its bulk of water. It is made as follows :—7 kilogs. of white Marseilles soap and 600 grammes carbonate of potash are dissolved in 100 litres of hot water, or 7 or 8 kilogs. of soft soap may be dissolved in 100 litres of hot water. To either of these solutions are added 500 grammes of extract of Panama-wood. This forms solution No. 1.

In a separate vessel mix 15 litres of ox or sheep's gall and 1¼ litre ammonia of 22° ; heat, skim, allow the mixture to cool, and add 15 litres of spirits of wine of 90°. This is solution No. 2.

A third part of solution No. 1 is mixed with two-thirds of No. 2, and a sufficient quantity of some aromatic essence added thereto. The article is intended as a substitute for gall for toilet and household purposes. *Moniteur Indust. Belge, 1st Oct.*, 1875.

New Process of Colour-Printing on Paper, Leather, &c.—M. J. P. DAGUZAN has invented a composition to replace the colouring matters usually employed in printing on paperhangings, leather, &c. The basis of the composition is caoutchouc in its natural state, which in certain cases may be replaced by gutta-percha or other natural gums. The base is reduced to a paste with benzine, and some organic colouring matter added in the requisite proportion. In practice feather-dust or fine clippings of wool, silk, &c., dyed to the desired tint, are used, but other colouring matters may be substituted if necessary. *Moniteur Indust. Belge, 1st Oct.*, 1875.

§ 4. *Food, Water, and Sanitary Matters.*

Fish Guano.—For several years past the manufacture of guano from the heads and bones of fish has been carried on in Norway on a very extensive scale. After drying in the sun the materials are passed through ovens, then cut in pieces by means of revolving steel discs, and finally ground to powder. One manufactory, at the mouth of the Tana, prepares 6 to 8 tons of guano daily. The establishment is valued at 110,000 fr., and in ten months of work has sent out guano to the value of 257,000 fr. at the average price of 27.5 fr. per 100 kilogs. *Revue Indust., 16th Oct.* 1875.

Improved Air-Cooler or Air-Saturater.—An apparatus for cooling or saturating air in dwellings and industrial establishments, constructed by CUAU and Co., of Paris, from the designs of MM. NÉZERAND and GARLANDAT, is figured and described in the under-mentioned journal :—

It is a rectangular chest divided horizontally into two separate chambers by a thin plate of metal, generally copper, perforated with holes of a diameter proportioned to the thickness of the plate, which has a certain amount of slope adjustible at will. Over this plate a stream of water, $\frac{1}{10}$ in. to $\frac{1}{4}$ in. in depth, and the colder the better, is kept trickling, the depth and velocity being regulated by adjusting the inclination of the plate. The air is driven by a fan into the lower chamber, rises through the perforations, becoming cooled by contact with the water in the process, and collects in the upper chamber, whence it is led off by pipes to its destination. The fan will drive from 1,000 to 25,000 cubic feet of air per hour. A pressure equivalent to 1 in. to 1½ in. of water is sufficient to enable the air to make its way through the perforations in the plate and the supernascent water. As a rule it leaves the upper chamber at a temperature of 1° to 1½° C. above that of the water with which it has been in contact. Experiments made in July, 1874, showed that an apparatus with a metal plate 1 m. long by 80 cent. wide, with perforations amounting to one-ninth of the total surface, and supplied with 1,200 litres of water per hour, would in that time reduce 1,000 cubic metres of air to a temperature of 13½° C., the initial temperature of the said air being 21° or 22° C. The fan and pumps were driven by a small vertical engine, and it was found that the quantity of air delivered could be increased, if necessary, to between five and six times the above amount.

Where the object is to reduce the temperature of the air in a building to about 15° C. (59° Fah.), and water of a temperature of 12° C. (53° Fah.) is procurable, the apparatus promises to be very useful. The full working of the apparatus requires a steam-engine or other motor, a pump, a well 20 ft. to 25 ft. deep, and the air-cooler itself with fan attached. For the delivery of 35,000 cubic feet of air per hour with a fan 2·5 m. in diameter, 30,000 litres of water will be needed, and a steam-engine of 8-horse power will work the whole with ease.

In establishments where steam power is used a special engine will not be necessary, and the water can be used in feeding the boilers, in which case the cost will be much reduced. In hospitals, where there is often a difficulty in maintaining a supply of cool fresh air in summer, the apparatus will prove very serviceable. The preliminary washing of the air is in itself beneficial, and disinfectants can be mixed with the water if desired. In theatres and public buildings, in markets, abattoirs, breweries, and wine-bottling establishments, chocolate manufactories, &c., it will also prove very useful.

By employing hot water, such as the condensation water of a steam-engine, the air may be charged with watery vapour, which it will part with on entering a cooler medium. In this way the dryness of the air may be counteracted in spinning mills when required. What should be the precise hygrometric state of the air in textile operations of this description is nowhere stated, and appears to be unknown to practical men. But it is a well-known fact that in dry summer weather the filaments often become so highly charged with electricity as to render it impracticable to work them up. The only remedy is to fill the rooms with steam from the engine. This effects the desired result, but the operatives labour under very unfavourable conditions, in what is, not figuratively but literally, a vapour bath. The employment of the apparatus just described as a saturater would probably admit of the substitution of an atmosphere charged with moisture sufficient for all practical purposes, but not to an extent likely to prove detrimental to the work-people. Experiments will shortly be made in this direction, and further details are promised. *Revue Indust., 8th Sept.*, 1875.

Fish Flour.—A novel and remarkable article of food, prepared from the products of the ocean, has been prominently brought forward within the last two years—this is fish flour. It is not as yet manufactured in any great quantity, as the article is still new in the market, and, consequently, there is no great demand for it. The flour is prepared in Norway from dried cod-fish of the very first quality ; it is thoroughly desiccated, and then ground in a mill. There are two qualities—the coarse and the fine ground. It is especially the former that has found favour with the public ; from it an excellent dish of preserved fish can be prepared in a few minutes, whilst the fine ground is used for fish-puddings—a dish highly appreciated in Norway and Sweden. In Catholic countries—in localities where there is no regular supply of fresh fish—it is presumed that this article will be more particularly important. *Journal of Applied Science.*

Soluble Extract of Blood as an Article of Nutriment.—When blood is pulverized by evaporation in the ordinary way, it forms an impalpable powder, as insoluble in water as sand. Its indigestibility is proved by the fact that it may be left for forty-eight hours in an acid solution of pepsine without undergoing the slightest change. The preparations sold under the name of "Extract of Blood" are scarcely more soluble, and spectroscopic analysis shows them to be destitute of *hæmoglobine*, which constitutes 86 per cent. of the globules.

LE BON claims to have discovered a process of extraction whereby the fresh blood is merely deprived of the ⅘ths of water in its original composition, without undergoing further change of any kind. The process consists in evaporation under reduced pressure, at a temperature not exceeding that of fresh blood, in a special apparatus. Powdered blood so prepared is perfectly soluble in water, easily digested in pepsine, and is shown by the spectroscope to contain a due proportion of *hæmoglobine*. Mixed with leguminous meal of various kinds, it forms an aliment

physiologically perfect, and contained in the smallest possible compass. Recent experiments in England, Sweden, and Russia, with blood in a fluid state as an element in the composition of portable food for troops in the field, are stated to have given satisfactory results hygienically, but the difficulty of preventing the decomposition of the blood has hitherto proved an insurmountable obstacle to its use. It is suggested that soluble blood in powder would prove of essential service in therapeutics, owing to its richness in iron and its tonic properties. *Comptes Rendus, lxxxi.* 13, *27th Sept.* 1875.

Refrigerated Fruit. — The "Irish Farmers' Gazette" writes as follows :—"We had this week brought under our notice a very interesting and noteworthy illustration of peach-farming on a colossal scale, and of Irish enterprise, as also of the successful transmission across the Atlantic and arrival in Dublin in excellent condition, of a quantity of ripe peaches gathered some three or more weeks since in the peach-orchards of distant Alabama !—this last a feat, so far as we are aware, hitherto unaccomplished, and which is to be credited to a countryman of our own, J. H. Parnell, Esq., of County Armagh, younger brother of Mr. Parnell, M.P. As well as in Armagh, Mr. Parnell, Junr., possesses property in Alabama, and resides there occasionally. Peach-farming is one of the most important industries in America, and, as illustrating it, we remember seeing it somewhere stated, that the shipment of peaches annually from the State of Delaware alone, in one season, was considerably over half a million baskets; and further, that the number of huge waggon-loads sent over the railway in one day, for supplying New York, was ninety-eight, and twenty-five for Philadelphia. That Mr. Parnell goes in for peach-farming on a pretty extensive scale in the South may be inferred, when it is stated that he has 10,000 trees in his peach-orchards, all or nearly all planted by himself and imported from England. Though only some three or four years planted, he is now enabled to supply River's Early Beatrice in quantity to New York as early as the month of June, and later kinds, as Crawfurd's Early and others, in July, when they bring £2 10s. to £5 the bushel, according to quality, the bushel containing 50 dozen. The present year, before leaving for Ireland, Mr. Parnell informs us he sold 2,000 boxes. But to come to the point that most concerns us here—fruit-growers and consumers — namely, the mode successfully adopted by him for bringing over a large quantity of ripe peaches from the Southern States to Dublin, and which we are of opinion might be advantageously adopted by our fruiterers, who may have to keep over choice melting fruits or to send them to long distances. On handling and examining one of the peaches brought by Mr. Parnell as a specimen—the very high colour notwithstanding—we confessed to being sceptical as to the ripeness, and remarked that it was hard as a stone. Mr. Parnell admitted it was, but promptly gave the reason why, by saying it was frozen, and that, if allowed to stand a day or two, it would be sound, soft, and melting enough. Mr. Parnell kindly took us to Fitzwilliam Square, North, where he is at present stopping, and showed us the ingenious contrivance by means of which he has been enabled to treat his friends in Ireland to the melting, juicy products of his peach-orchards in as good condition as though pulled from one of our own house or wall-trees the day before. This contrivance consisted of a large square bin or deep wooden chest, strongly put together, and lined with zinc ; within this was another large chest similarly lined, a space of 8 or 9 inches intervening between the outer and inner chest, which was filled with ice. In the inner chest the peaches were stored, not in separate trays, layers, or anything of the kind, but heaped as you would stow potatoes in a pit, and there they lay, a rosy and happy-looking mass, in the best possible condition. In a compartment separate from the peaches were some remarkably fine specimens of the water-melon, far superior, Mr. Parnell informed us, to the Spanish water-melons imported by our fruiterers ; indeed, so much so that those acquainted with the former would not think of eating the latter. It is scarcely necessary to say that the condition of the melons was all that could be wished for. The peaches were Crawfurd's Early, a yellow-fleshed, very highly coloured variety, but small, and one very much larger, called by Mr. Parnell White Clingstone."

Sherry.—Spain has been for all historical times one of the most important wine-producing countries of the globe. The mountains, which follow the course of its numerous rivers, offer the most favourable situations and fertile soils for the culture of the vine ; its southern position insures a sufficient amount of sunshine to fully mature the grapes and bring them every year to their highest state of perfection, while the proximity of the Atlantic Ocean on the one hand, and the Mediterranean on the other, brings the natural moisture necessary to the best development of the fruit.

It is in the preparation of white, dry wines, such as sherries that the Spanish excel all other nations, and the export trade in these products, which is carried on to most parts of the world, is, perhaps, the most notable source of wealth to the inhabitants of the Peninsula.

True Sherry wines are the products of the district of Cadiz—the most important maritime town of Spain, situated on the bay which bears its name—in the province of Andalusia. Thirty miles by rail from Cadiz, on the road to Seville, the capital of the province, lies the town of Xeres De La Frontera, around which the principal vineyards are situated. A horse-car—a novelty in Spain—takes the traveller from the station to the town, the population of which is about 40,000.

Xeres, or Jerez, has the same connection with sherry wine that Bordeaux has with claret, or Rheims with champagne ; in fact, a closer one, as it is not only the place where the wine is produced, but even the name is derived from the town ; the English having first changed Xeres, the Spanish name for the wine, into Sherris, and finally into Sherry.

The vineyards lie between the rivers Guadalquivir and Guadalette, in a triangular space, measuring about twelve miles on a side. The actual number of acres devoted to the culture of the vine in the Cadiz district is about 25,000, while the annual production of wine is about 50,000 butts of 106 imperial gallons each. The vineyards are principally on slopes and declivities, and, in those vineyards producing the best wine, contain a soil composed of the carbonates of lime and magnesia mixed with clay.

The grapes, which are white, are left to hang in the sun till they begin to shrivel, when they are gathered and carefully sorted for the better wines. The fruit, dusted over with plaster of Paris, is placed upon large wooden platforms, where it is trodden on by men ; the juice which runs from the grapes is by some producers kept separate, but by others it is mixed with that obtained by the use of the press after the treading. The juice is filled into butts, and these are transferred to the *bodega*, or store-house. Here, during the months of December, January, and February, the must ferments. After the first fermentation is over, the liquor is racked from the lees, and each new butt of new wine receives an addition of spirit, varying, according to the wine, from six to ten gallons. The common sorts are clarified and mixed with further quantities of spirit, so as to be in a condition for export eighteen months after the vintage, but the better sorts remain in the cask for two or three years before their sale can be contemplated.

When the wine is about to be exported, a small quantity of very fine old wine, or *solera*, is mixed with it, which increases the desired sherry flavour.

The ordinary wines contain a considerable amount of albuminous matter, which disposes them to spoil, and therefore, in the absence of a more desirable preservative agent, a sufficient amount of brandy is added to stop all change ; but it is impossible to say how much of the alcohol of any particular sherry is natural, and how much is artificial. The best natural sherries, however, never contain more than about 12 per cent. of absolute alcohol, while inferior varieties contain as small an amount as 8 or 9 per cent., and frequently even less. Sherry, as sold in our market, contains from 17 to 23 per cent. of alcohol, so that the addition of brandy, or "fortifying," as it is called, is seen to be very considerable.

All sherry wine is by nature of a pale colour ; the darker shades, or brown sherry, are produced by age, or the addition of *vino de color*, or boiled wine.

Good sherry wine is very scarce ; at the present time it is necessary to pay £60 per butt of 106 gallons, on the spot where the wine is produced ; inferior grades can of course be obtained at much lower rates, the common ordinary wine of the country costing only about 6*d.* per bottle.

Sherry wines have one great advantage, which is, if they are of the best quality, that the older they get the better they are ; but it is an error to keep low-priced wines in the expectation of their becoming good after a time—very generally the reverse is the case, and they turn out fit for nothing.

The choicest variety of sherry, and of course the highest in price, is the famous Amontillado ; but the supply is not equal to the demand, nor can it be increased, as a soil similar to the little calcareous tract at Jerez, possessing like advantages of climate, is unknown. But in other places where the real vinous basis cannot be obtained the chances of profit have lured many into the dishonest practice of adulteration. Even Cadiz has earned an unenviable notoriety, by dishonest shippers lending themselves to the frauds of London wine-merchants, who, according to a recent wine-circular, obtained the cheapest liquid trash they could find, to make a counterfeit, which they shipped to Cadiz, to be brought back as genuine sherry, with a bill of lading dated from that Spanish port. *Journal of Applied Science.*

Cement Casks for Wine.—Attention is called to the advantages presented by these casks. They effect an immense saving of room, as compared with ordinary wooden casks; are cheaper, stronger, and more durable; are less exposed to leakage, and the wine in them is better protected against atmospheric influences and keeps a more uniform temperature. On the other hand, until seasoned, they induce an abnormal deposit of tartar, owing to the action of the potash in the cask on the salts contained in the wine. *Stummer's Ing., 17th Sept.*, 1875.

Meat-Preserving with Compressed Air. — The ABBÉ MOIGNO relates the following incident illustrative of the powerful and enduring effects of compressed air as an antiseptic. Several months back a small piece of breast of mutton, which had been treated with compressed air by M. Alfonso-Reynoso's patent process, was taken out of the air-chamber and forgotten. Some weeks afterwards it was found dried up, but with its colour and fresh odour unimpaired—in fact, in a state of perfect preservation. Himself surprised at the permanence of the results, M. Alfonso-Reynoso determined to repeat the experiment on a larger scale. A half-carcase of lamb was hung for several weeks in an atmosphere of compressed air, and then taken out and cut into quarters. One quarter was submitted to connoisseurs, who pronounced it excellent; the other was exposed in a room in No. 40, Rue Chateaudun, being merely wrapped round with muslin to prevent the flies settling on it. The same result was attained as with the smaller joint—the lamb gradually dried but retained its natural colour and sweetness unimpaired, and had all the taste of fresh meat, so energetic and enduring had been the antiseptic action of the compressed air to which it had been exposed. Here, then, is a process, of ultra-simplicity, admitting of daily application on a large or small scale, which gives promise indeed of a brilliant future. *Les Mondes, 23rd Sept.*, 1875.

Influence of Season on the Skin.—DONHOFF calls attention to the fact that the obvious difference between the fur of animals in summer and in winter is associated with an equally striking difference in the texture and thickness of their skins. Thus, for example, the average weight of an ox-hide in winter is 70 lbs., in summer 55 lbs.; the hair in winter weighs about 2 lbs., in summer 1 lb., leaving about 14 lbs. to be accounted for by the proper substance of the skin. These differences are quite as decided in fœtal animals as in adults. Calves born in winter have a longer and thicker coat than those born in summer; moreover, there is a difference of more than a pound in the average weight of their skins after the hair has been removed. Similar facts may be observed in the case of goats and lambs. That these differences are not to be ascribed to any corresponding change in the diet and regimen of the parent animals is proved by the fact, that they are equally manifest in the young of individuals kept under cover and on the same food all the year round. *Veterinary Journal, September*, 1875, *from Reichert and Dubois Reymond's Archiv.* 1875.

Copper in Distillates.—BOUSSINGAULT has lately called attention to the presence of cuprous salts in *Kirschwasser*. DR. PETERMANN, Director of the Belgian Agricultural Station at Gembloux, notes their frequent occurrence in gin and in the residuary products of gin-distilleries. That gin, especially when prepared from grain that has been impaired by damp, not unfrequently contains a small percentage of acetate of copper is no new fact. Medical writers have not been wanting to attribute the evil effects of the continued use of alcoholic drinks, in part at least, to the cumulative effects of copper thus introduced into the system. Distillers, too, have long been in the habit of placing strips of bright tin or tin filings in their vats to ensure the precipitation of these salts. But their presence in the residuary products of distillation, as in the grains now so largely used as food for cattle, has been generally overlooked. A sample of farm-yard manure, sent for analysis to Gembloux, showed a very decided copper reaction, which could not be accounted for. Subsequent analysis of the grains on which the animals had been fed showed the presence of a notable percentage of copper, leading to the inference that the copper in the dung had passed through the animals' system into the dung. As cattle not unfrequently consume from 80 to 100 litres of grains per head daily, the fact appears worthy of note. *Moniteur Indust. Belge, 20th September*, 1875.

Employment of Salicylic Acid in Wine.—Without calling in question the reported action of salicylic acid on cryptogamic vegetation in general, and on *ferments* in particular, we would remark that the fact must not be overlooked that the presence of ferment is not only unobjectionable, but even absolutely necessary in certain phases of wine-making. It is evident that even when all sensible fermentation has ceased, the *rôle* of the ferment is not played out, its presence being still indispensable to the gradual development of the most delicate organoleptic properties of the wine. It remains for us to determine, by continued and intelligent research, the exact moment at which the salicylic acid should be applied, knowing that all ulterior improvement of the wine, in a gastronomic sense, is then at an end. One thing is certain, that in the opportune application of this acid we have a most valuable means of fixing the wine when at its best in respect of bouquet and flavour. As regards the proportion of the acid to be added, we shall probably have long to rely on empirical experiment. According to Neubauer's experiments, 100 grammes of salicylic acid is the maximum for 1,000 litres of must, rendering all ulterior fermentation impossible, and utterly destroying the fermentative germs, which have their origin, not in the juice, as originally supposed, but in the skins of the grapes. Taking this proportion as the full dose—and there is no doubt that a less quantity would suffice to prevent secondary fermentation—it should not be forgotten that Weidenbusch found it necessary to use 800 grammes of acid for 1,000 litres of must in active fermentation, and 400 grammes to prevent the formation of flowers of wine in a clear one-year-old wine, 200 grammes having proved insufficient for the purpose. This shows the absolute necessity of a special consideration, in every individual case, of the proportion of acid to be added. So far as our knowledge at present extends, the following appear to be the conditions under which salicylic acid may be usefully employed in wine:—

1. To conclude the secondary stage of fermentation in new wines, and render them fit for sending out.
2. To check any renewal of fermentative action in wines having a tendency to become acid, and to bring them into a suitable condition of rest.
3. In the treatment of wines destined for the tropics, as an infallible preventative of degeneration and decomposition.
4. To prevent a renewal of fermentative action when wines of different ages are mixed together.
5. To prevent wines in half-filled casks flowering and turning acid.
6. To prevent the formation of mould and other changes in casks destined to receive new wine.
7. To purify casks that have become mouldy, and fit them for the reception of sound wines.

In every case the salicylic acid should be previously dissolved in spirit of 80°, as its solution in wine alone is slow and tedious. The quantity judged suitable should be poured in in a thin stream, the wine being well agitated at the same time. *Technologiste, Sept.* 1875, *from Die Weinlaube.*

Solubility of Salicylic Acid.—E. TOUSSAINT reports the following experiments with a view to the dispensing of salicylic acid in a form readily soluble in water:—

1. Dr. Squibb has recommended phosphate of soda in the proportion of 3 parts phosphate to 1 salicylic acid.

By dissolving it in hot water, the reporter found phosphate of ammonia to be more powerful than the soda salts. Twelve parts salicylic acid require 11 of phosphate of ammonia, or 1 drachm of acid to 1 drachm of ammonia phosphate.

2. Salicylic acid is very soluble in a small quantity of diluted ammonia water and a solution of carbonate of ammonia. Neutralized by it, and evaporated by means of a water-bath, its crystallization is just visible.

The salicylate of ammonia is probably more easily decomposed in the system than the salicylate of soda and potash. So it appears more suitable for medical use.

Further experiments show:—

1. 30 grains of salicylic acid are soluble in 1 oz. of glycerine heated in a water-bath at 180° F. The specific gravity of the glycerine is 1·26 (30° Baumé). Cooled to 70° F., the greater part of the acid crystallizes again.

2. 15 grains of salicylic acid, 5 grains phosphate of ammonia, and ½ oz. glycerine, dissolved in heat, and then cooled to 70° F., become a crystalline mass.

3. 10 grains salicylic acid and 10 grains ammonia phosphate, dissolved in 2 drachms of water, and mixed with 2 drachms glycerine, form a clear liquid.

4. 15 grains of salicylic acid, 15 grains phosphate of ammonia, dissolved in 2 drachms water, and mixed with 4 drachms glycerine, and afterwards heated in a water-bath, remain very clear without sediment. *American Chemist, August*, 1875.

"Oleo-Carburet"—a Mineral Oil Lubricant, and Antiseptic.—In a memoir on "Oils used as Lubricants," addressed to the Mulhouse Industrial Society, MM. FAREZ and BOULLANGER, oil-refiners of Douai, describe a product, designated by them "Oleo-Carburet," resulting from the partial distillation of mineral oils with super-heated steam, which they assert to be the best and safest lubricant yet discovered.

Premising that the requisites of a good lubricating oil are three in number,—*unctuosity, neutrality*, and *unalterability*,—they observe the two latter are possessed in a high degree by mineral oils. Experiments in the arsenals at Douai and Cherbourg have shown the value of these oils in preserving metal surfaces. The experiments of M. Cornut at the flax-spinning mills at Hamégicourt, Aisne, which have been published from time to time in the "Bulletin" of the Industrial Society of Lille, conclusively prove their utility as lubricants in regard of the *speed* of machinery. But they have two drawbacks:—they assume a high degree of fluidity at temperatures above the ordinary, which renders them unfit for bearing surfaces where there is much pressure, and they possess a high degree of inflammability, which is a constant source of danger. Samples of cheap mineral oils sold for lubricating purposes were found, in some instances, to give off inflammable vapours at temperatures of 60° to 65° C. (140° to 150° Fahr.)

A careful study of the rock-oil much used in America under the name of "Lubricating Oil," which is not inflammable at temperatures below 100° C., led MM. Farez and Boullanger to believe that the volatile and inflammable constituents of ordinary petroleum oils could be got rid of without detriment to their cheapness and lubricating power. This they effect by distillation with a jet of superheated steam, which they find to be far preferable to pyrogenous distillation, as not only is the heat less intense, but the partial decomposition of the oil is less, and the formation of lighter inflammable carburets is avoided, whilst the direct action of the steam on the oil facilitates the subsequent purification. The process is equally applicable to the preparation of mineral oils for illumination and other purposes. Experiments have shown that oils so treated remain permanently uninflammable at temperatures below that at which distillation has been arrested. Ordinary petroleum oils thus partially distilled, and subsequently purified by agitating successively with sulphuric acid, caustic alkali, and water, constitute the substance called "oleo-carburet"—the type of the class being an oil the distillation of which has been arrested at 220° C. (428° F.), and which consequently is uninflammable at any lower temperature. It is amorphous, of the consistency of syrup, opaque, and of a dark green colour in the mass, yellow and transparent in thin films. Its *unctuosity* is superior to that of any mineral oil, and is retained at a very high temperature; its *neutrality* and *unalterability* are absolute. It can be used as a lubricant either alone or mixed with other oils—animal, vegetable, or mineral. These mixtures should be made, if possible, in a water-bath at a temperature of 100° C., the mixture being left therein until it becomes perfectly limpid.

The subjoined experiments show the effect of oleo-carburet in lessening the inflammability of other oils. The temperatures given are those to which it was found requisite to raise the mixture to produce instantaneous ignition when a lighted match was passed across the surfaces:—

1. Boghead oil, inflammable at 80° C., was mixed with oleo-carburet inflammable at 210° C. The mixture proved to be inflammable at a temperature of 125° C.
2. Same experiment repeated:—Mixture inflammable at 132° C.
3. Same experiment repeated:—Mixture inflammable at 148° C.

The following experiments were made with organic oils:—

Mixtures of certain oils with common mineral oil.	Mixtures of certain oils with oleo-carburet.
1. 1 part lard oil mixed with 2 parts petroleum oil of 860 sp. gr., inflammable at 118° C.—Mixture inflammable at 148° C.	6. Equal parts colza and petroleum. Sp. gr. at 17° C., 880.—Mixture inflammable at 135° C.
2. Same experiment repeated.—Mixture inflammable at 159° C.	7. 1 part olive oil mixed with 2 parts oleo-carburet.—Mixture inflammable at 244° C.
3. 1 part olive oil mixed with 2 parts petroleum, as above.—Mixture inflammable at 149° C.	8. Equal parts olive oil and oleo-carburet.—Mixture inflammable at 265° C.
4. Equal parts olive oil and petroleum. Sp. gr. of mixture at 17° C., 884.—Mixture inflammable at 160° C.	9. 1 part colza and 2 oleo-carburet.—Mixture inflammable at 244° C.
5. 1 part colza and 2 petroleum. Sp. gr. of mixture at 17° C., 876.—Mixture inflammable at 125° C.	10. Equal parts colza and oleo-carburet.—Mixture inflammable at 245° C.
	11. 2 parts colza mixed with 1 part oleo-carburet.—Mixture inflammable at 264° C.

The power of resisting oxidation, which oleo-carburet has been shown by experiment to possess in the highest degree, no only prevents the hardening of the oil on bearing-surfaces—a consideration of paramount importance in a lubricant—but also obviates the risk of spontaneous combustion arising from the oxidation of rags and waste impregnated with the oil.

Oleo-carburet is not dearer than corresponding mineral oils. It is a powerful antiseptic. Cat-skins, which had never been properly cleaned, were kept sound for two years by a dressing of oleo-carburet—even the hair did not fall off. Wood steeped in the same was buried for ten years in damp soil without decaying. Some worm-eaten carvings, which were dropping to pieces with age, in the Ethnological Museum at Douai, were given a coating of oleo-carburet, which effectually and permanently arrested the progress of decay. *Bulletin de la Société Industrielle de Mulhouse, July*, 1875.

In reporting on the above, at the request of the Mulhouse Society, MM. Eugène and Gustave Dollfus confirm the inventor's statements with certain reservations. They state:—

1. That oleo-carburet undoubtedly increases the *viscosity* of other oils, particularly mineral oils, when mixed therewith.
2. Oleo-carburet greatly diminishes the inflammability of oils with which it is mixed. A mixture of 30 parts oleo-carburet with 70 of heavy petroleum oil is only inflammable at 142° C. A mixture of colza and petroleum in like proportions inflames at 128° C.
3. Oleo-carburet increases the unalterability of the substances with which it is mixed, so that bearings lubricated therewith are less liable to clog.

But they add:—

In mixtures of mineral oil with oleo-carburet, the latter is very apt to separate at low temperatures, which is productive of inconvenience. The smell is likely to be injurious to the health of the work-people. The price, 85 to 90 fr. per 100 kilogs., is high for lubricating purposes. *Bulletin de la Soc. Indust. de Mulhouse, August*, 1875.

§ 5. *Fuel, Heating, Illumination, &c.*

Illuminating Gas from Cork.—Repeated experiments at Bordeaux have resulted in the manufacture of illuminating gas of very superior quality from cork-cutters' waste, by distillation in close vessels. The gas is heavier than ordinary coal gas, and gives a whiter and more brilliant flame. In localities where cork-cutting is carried on upon a large scale, the discovery will prove of considerable advantage. *Gaceta Indust.* (*Madrid*), 10*th Sept.*, 1875.

§ 6. *Miscellaneous.*

Applications of Cheap Oxygen.—Besides aiding in the preparation of platinum, oxygen has found other practical uses. It is not now employed in the autogenous soldering of lead, as hydrogen or common street gas burned in atmospheric air is found to give heat sufficient. But a more extended sphere of utility may be anticipated for it in respect of other metals. A well-known practical metallurgist, Carl Winkler, writes:—"Just as soldering platinum vessels with gold spoils their appearance by producing yellow seams, so on coloured metals the whiteness of ordinary solder is objectionable. This consideration has induced the Prussian Gewerbe Verein to offer a prize for the discovery of a good yellow solder—a problem not very likely to be solved until some new metal of a red or yellow colour and easily fusible, is discovered. It were better to turn our attention to the *autogenous* soldering of metals with the oxy-hydrogen flame—a method which has already been applied with perfect success to the union of dissimilar metals. Would it not be possible in this way to solder each metal and alloy with itself, tin with tin, copper with copper, silver with silver, brass with brass, and so on, just as platinum is now soldered with platinum and lead with lead? In all probability it could be done, and the advantages of such a method are obvious. Picture the elegance and simplicity of a workshop where a light and simple gas-jet has replaced the soldering iron and the forge! Imagine a workman no longer scorched by an open forge-fire or half stifled with the smoke, and enabled to apply the required temperature instantaneously and as readily to remove it by the mere turning of a stop-cock! Conceive, too, the solidity of the union so effected, depending as it would, not on the cementation of two pieces of metal by some foreign substance, but on their actual amalgamation; not to mention the saving in material and in after labour, as in filing down the joint, &c. Surely advantages

so obvious should vanquish prejudice, and induce us to experiment in this direction without delay."

In another, wider field—the manufacture of iron and steel—technologists of high standing have predicted important advantages from the use of cheap oxygen. Calmeron recommends oxygen, or air rich in oxygen, such as is furnished by Mallet's cylinders, for blast furnaces, in place of common air, and here it may be observed that the absorption of oxygen by water has been undesignedly turned to account for the same purpose, although in a shape admitting of improvement. Kerl has noticed that the air of a wet blast is richer in oxygen than common air. It has been found, too, that coal that has been long exposed burns faster than fresh, owing to its having absorbed oxygen from the atmosphere, a fact which has been recognized in welding iron. Kuppelweiser recommends oxygenized air for the treatment of white cast-iron by the Bessemer process, and thinks that Tessie du Motay's estimate of the cost of oxygen need not be materially reduced to allow of its employment with profit. Here an important feature appears to await the advent of cheap oxygen. An objection urged by Le Blanc must not, however, be overlooked. This is the necessity of a more infusible description of crucibles, furnaces, &c., the additional cost of which would render the advantages of the process somewhat problematical. Turning to the subject of illumination, we find that the practical utility of oxygen has been generally admitted ever since Drummond's discovery of the oxy-hydrogen light in 1826, and its successful application to geodetical purposes and coast illumination. But, since the price was lowered, it has met with more extended application, of which the most notable example is afforded by the operations of an American, H. Vogel, at New York, in 1870, by whom it was applied not only to lighthouses and telegraphic purposes, but to engineering operations under water, &c. The works under water at the Brookly bridge over East River, then in course of construction, were lit with oxy-hydrogen lamps, consuming 2,000 cubic feet of oxygen daily. Zircon points were used in place of chalk, and found to last longer. In Paris, the Gaiété and Alcazar theatres were brilliantly lit in the same way. At the Opera House at New York a drop scene was lit up with powerful lenses and an oxy-hydrogen lamp placed 25 m. distant in the pit, and produced a very striking effect. The oxy-hydrogen light has been also much used in America with the magic lantern for projecting photographic and other demonstrations on the walls of lecture-rooms, especially since Outerbridge suggested the employment of thin sheets of gelatine for lithographic or other diagrams. The advantages of the light are evident, when it is remembered that photometrically its value is 16½ times that of a jet of ordinary gas of the same size. The quantity of oxygen manufactured daily by the New York Company in 1870 was 30,000 ft. It was delivered in iron cylinders (R. Grant's patent) 9 in. in diameter and 30 in. deep, which were filled with oxygen under a pressure of 20 to 30 atmospheres. Oxygen at atmospheric pressure sold, the cylinder included, at 1 dollar the cubic foot. At a pressure of 1 atmosphere, the oxygen, without the cylinder, sold at 50 cents the cubic foot, an extravagantly high price, according to Kuppelweiser's estimate, seeing that Tessie du Motay's process was employed in the fabrication.

So long ago as 1867, Tessie du Motay experimented on the application of oxygen to street illumination. The Place des Tuileries and that of the Hôtel de Ville were lighted by means of zircon cylinders supplied with a mixture of oxygen and street gas. The unsteadiness of the flame and the cost led to the substitution of a mixture of hydrogen and street gas, which, before reaching the jet, was passed through a vessel containing some heavy hydrocarbonate attached to each lamp. This in turn gave place to a mixture of carburetted hydrogen and oxygen. The latter method was tried at the Elizabeth station of the West of Austria Railway during the Vienna Exhibition. The following graphic account is taken from a manuscript report addressed by Herr Karl Haase, manager of one of the gas-works at Berlin, to the Municipal Lighting Committee :—

"The appearance of the Elizabeth station and the approaches, lighted up with a mixture of oxygen and carbonized hydrogen, was most striking. The light emitted by the small blue flames of the mixture is peculiar, and will not suffer by comparison with that produced by any other mode of illumination. The green of the trees and shrubs, the hues of the dresses, and the forms of the spectators stood out with wonderful distinctness. Every detail of colour or outline was clearly distinguishable as in broad daylight, and yet the eye was not fatigued. In the second-class waiting-room the effect was still more marked. Here a couple of by no means large jets showed every object, down to the minutest details of the decorations, in full relief. But the most striking illustration was afforded in the station itself, where one platform was lit up by the new method, and the other with a mixture of oxygen and street gas. The latter was of excellent quality—equal photometrically to 24 wax candles—and the jets were twice as numerous as on the opposite platform, yet the new arrangement gave far the most brilliant effect."

M. Haase considers, nevertheless, that the method is unsuited to general and private use. The brilliancy would be counterbalanced by the cost, which, in Berlin, would be twice that of common street gas for equal photometric powers. Then, too, consumers would not always be able to adjust the proportions of the two gases; the oxygen would deteriorate in passing through long pipes; the cost of maintenance of a double set of mains and pipes would be very heavy, &c., &c. But for special purposes, public buildings, and certain shops, as *magazins des modes*, the arrangement would be well suited. This opinion is diametrically opposed to that of Schiele, but quite accords with the report of Le Blanc to the municipality of Paris. *Hoffmann's Berichte über die Entwickelung der Chem. Indust., continued in Les Mondes, 2nd Sept.*, 1875.

Oil of Elæococca Vernicea.—M. CLOEZ furnishes details of experiments with an oil obtained from the seeds of *Elæococca Vernicea*, the oil tree of China (in Chinese, Tung Yeou). The tree, which is plentiful in China and Cochin-China, belongs to the tribe of crotons, and bears capsular fruit containing numerous seeds, each inclosed in a thick fleshy endocarp. The seeds experimented upon were imported direct from China with a view to the introduction of the tree in Algeria. With adequate cold pressure they yielded about 35 per cent. of viscid, colourless, inodorous, and nearly tasteless oil. Crushed and treated with ether, the yield was somewhat larger. At 15° C., the product showed a specific gravity of 0·9362. This oil, which exhibits several remarkable physical properties—amongst others that of solidification unaccompanied by any change of composition under the influence of certain rays of the spectrum, the white and violet, without exposure to the air—is stated to be more highly siccative than any oil yet discovered. Spread in a thin film over a sheet of glass or a clean metal plate, it dries up completely after exposure to the air for a few hours. *Comptes Rendus, lxxxi.* 11, 13*th Sept.*, 1875.

Imitation Leather (Cuir Liege).—This material is in fact a preparation of cork. Cut in fine sheets, or in strips, and covered on either side with a skin of india-rubber, it wholly loses its friability, whilst retaining every other advantage. Cork thus treated may be wrung out like a dish-cloth, doubled into any shape, and beaten with a mallet, but suffers actually no damage. It is, of course, perfectly water-tight, and the inventor shows (at the Paris Exhibition) buckets of every size, which fold like a handkerchief to put away. Some have been full ever since the opening of the exhibition. But *cuir liége* claims also to be heat proof, a quality that should make it invaluable for ambulance tents, for awnings, and for tropical uses. It may, in short, be said that every purpose served by leather professes to be filled by this new substance, with the further recommendation of feather lightness and impermeability. Its strength is such that a strap 1¼ in. wide has been holding a 1,000 lb. weight for the last six weeks. In thicker sheets veneered with fancy wood, it is suggested as a material for carriage-building. Most elegant boots, as well as hats and portmanteaus, all made of it, are shown. It is also claimed that military accoutrements, knapsacks, and straps, belts, and pouches, &c., can be lightened 70 per cent., rendered water and heat proof, and manufactured at 25 per cent. below present cost as well, by substituting *cuir liége* for ordinary leather. *Furniture Gazette, 2nd Oct.*, 1875.

International Exhibition of Electrical Apparatus.—An international exhibition of the applications of electricity to *industrial* and *domestic* purposes is to be held at the Palais d'Industrie, Paris, in July, 1876. Particulars may be obtained at the offices of the exhibition, which are now open at 86, Rue de la Victoire, Paris. *Revue Indust., 22nd Sept.*, 1875.

Estremadura Phosphorite.—The "Porvenir de l'Industria" states that, notwithstanding the frequent interruptions of the communications, 50,000 tons of this material (for analysis, see "Practical Magazine," July, 1874, p. 10) were exported from Spain in the course of 1874.

Paper-making in Spain.—In the province of Alicante there are at present 58 manufactories of paper—viz., 47 of cigarette papers, 1 ditto and vellum, 9 of brown, and 1 of packing papers. Of these the first forty-eight turn out 403,438 reams, the next nine 7,400 reams, and the packing-paper manufactory 3,000 reams annually. They give employment to 2,216 operatives, of whom 1,342 are men, 110 women, and 764 children. Water is the motive power in all, with the exception of four, which employ auxiliary steam-power. The price of

cigarette paper varies with the quality, from 3 pesetas 75 centimos per ream to 7 pesetas 5 centimos. The brown paper varies in price from 1 peseta to 1 peseta 25 centimos, and the packing papers from 2 pesetas 50 centimos to 7 pesetas 50 centimos. These manufactures are situated in the towns of Alcoy, Concentaina, Elda, Tibi, Ibi, Muro, Bäneras, Alqueria de Aznar, and Alcocer de Planes. *Gaceta Indust.* (*Madrid*), *25th Sept.* 1875.

CARS FOR REAPING MACHINES.

WE copy from "Stummer's Ingénieur" the accompanying figures of a car, designed and built by M. Henry, of the Machine Works, at Abillard (Indre et Loire), for transporting reaping and other farm machines, thereby obviating the inconvenience and loss of time experienced in moving them over unsuitable ground. Each car is fitted for one horse draught, and runs on a single pair of wheels of any desired breadth. Light iron supports let down at will under the shafts and under the tail of the car, and at the back of the shafts is a small windlass, to assist in loading. In the field these cars can be used for carrying when not otherwise employed.

AN ELEMENTARY TREATISE ON STEAM AND THE STEAM-ENGINE.[1]

THE series known as "Weale's Rudimentary Scientific and Educational Series," of which the volume before us is one, has now been for many years in existence, and has been growing in size as it has advanced in years. Evidence of the vitality of the volumes in this series is given by the constant re-issue of the older works, revised and re-written so that they may keep pace with the numerous discoveries and rapid scientific movements of our modern times.

This volume on Steam and the Steam-engine is an instance of what we have just alluded to. Mr. Sewell's original work published under this title has been entirely re-cast, and to a considerable extent re-written. The only portion of the original work that has been retained is that which gives the record of the inception and growth of the steam-engine—the new matter now given refers, of course, to the later advances of scientific investigation and experience, such as, for instance, the mechanical theory of heat, and the various modifications of the steam-engine which have been introduced within the past few years.

A Treatise on Steam and the Steam-engine, comprised within the space of 350 pages, not over closely printed, and with numerous large diagrams interspersed, cannot, of course, go very minutely into details, and the effect of such a work is, no doubt, one of breathlessness and hurry on the mind of the reader—it is, nevertheless, as complete as might be expected, and whoever desires to gain a general and rudimentary knowledge of the subject cannot do better than procure this work.

AN INTRODUCTION TO ANIMAL PHYSIOLOGY.[2]

WHEN noticing some few months ago[3] a work on Inorganic Chemistry, which was published in the same series as the present work, "Murby's Science and Art Department Series of Text Books," we expressed our gratification at finding in it very few, if any, of the characteristic features of a cram-book, and we are glad to find that this other volume of the series is equally free from them. It is a carefully compiled introduction to the subject, aided by a large number of woodcuts taken from the best available sources. Each part is fully described before its uses are referred to, and the work is prefaced by a simple sketch of human anatomy and physiology, the various parts being afterwards treated of separately and in detail.

An excellent feature in this book, and one which, considering the small size of the volume, is exceedingly well done, is the notes appended to each chapter in smaller type, headed Practical Section.

The instructions given in these sections commence with the simplest directions for practical work, leading the student gradually up to the more complex and difficult dissecting operations. In connection with this we may also refer to the final chapter, which is devoted to Practical Histology, and which gives some excellent instructions to the student for the preparation of the various parts for microscopical examination. In a word, we may say that this is a very useful compilation, which will be found of service alike by the beginner and by the more advanced student.

SEXTON'S POCKET-BOOK FOR BOILER MAKERS AND STEAM USERS.[1]

THIS is really a valuable and much-needed contribution to our practical literature, and one which cannot fail to meet with a widely extended and appreciative recognition. It is got up in the well-known style of Messrs. Spon's other works on practical subjects intended for the pocket, and it will prove a most valuable acquisition to employer and workman alike, to government inspectors, Board of Trade surveyors, engineers in charge of works and ships, foremen of manufactories, and to the general steam-using public. The author's qualifications for the work are indisputable, and he has produced a most complete and valuable work. Numerous carefully compiled tables of circumferences of circles of various thicknesses and from 10 ft. to 8 ft. in diameter; lengths of bars required for angle iron rings, weights of iron, proportions of boilers, circumferences and areas of circles, &c. &c., are given, and the letterpress, which is a very complete miniature treatise on the subject of boiler-making—a subject by the way that has but a very limited literature of its own—is carefully and concisely written, and illustrated with several well-executed diagrams.

We cannot do better, in conclusion, than repeat the author's words, which after carefully examining the work we are able to confirm. They are as follows: "All abstruseness or ambiguity will be avoided; and really the possessor will not have to make any calculations—a thing to be always avoided in the hurry and excitement of working hours—but will find in the following pages an answer to every question that in the ordinary course of business can possibly suggest itself."

PROGRESSIVE LESSONS IN APPLIED SCIENCE.[2]

THE ordinary student, fresh from the study of his school Euclids, is nearly always in a state of hopeless fog as to the practical applications of the science to the acquisition of which he has so laboriously applied himself; and he not unfrequently asks what has been the use of his lengthened study of the wearying propositions of the first great exponent of the science. With the aid of such a work as these two volumes by Mr. Sang, he would quickly see the tangible and definite uses to which his knowledge might be applied, and, notwithstanding the numerous attempts at an exemplification of the science which already exist, we believe that, in compiling and in giving this work to the world, the author has conferred a real benefit on the student of applied science.

In this short course of the study of practical geometry, which is here considered in its widest application, and is held to include measurements of all kinds, the author has not confined himself to the mere qualities of the size and shape of matter, but has taken cognizance of the "accidentals" of the subject,

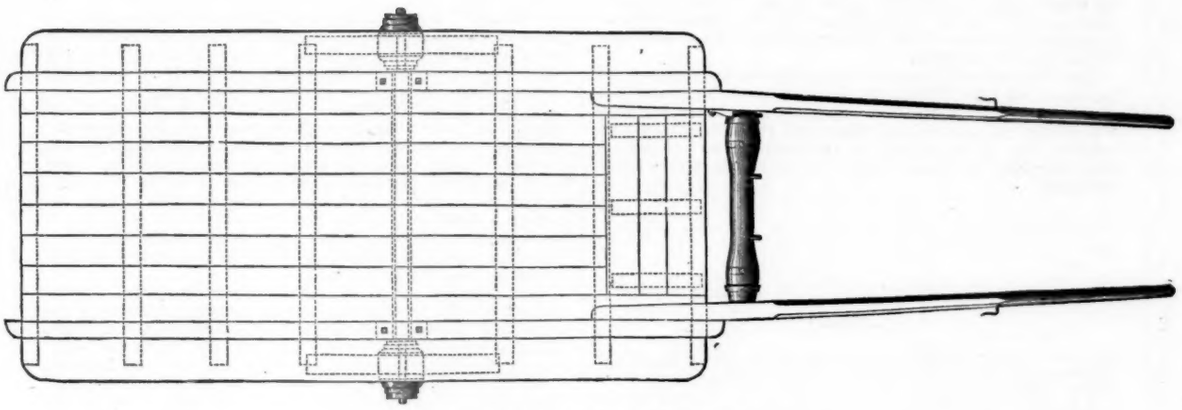
[1] *An Elementary Treatise on Steam and the Steam Engine, Stationary and Portable; (being an extension of the Elementary Treatise on Steam by Mr. John Sewell.)* By D. Kinnear Clark, C.E. With numerous Illustrations. London: Lockwood and Co. 1875.

[2] *An Introduction to Animal Physiology, with directions for practical work.* By E. Tulley Newton, F.G.S. London: Thomas Murby, 1875.

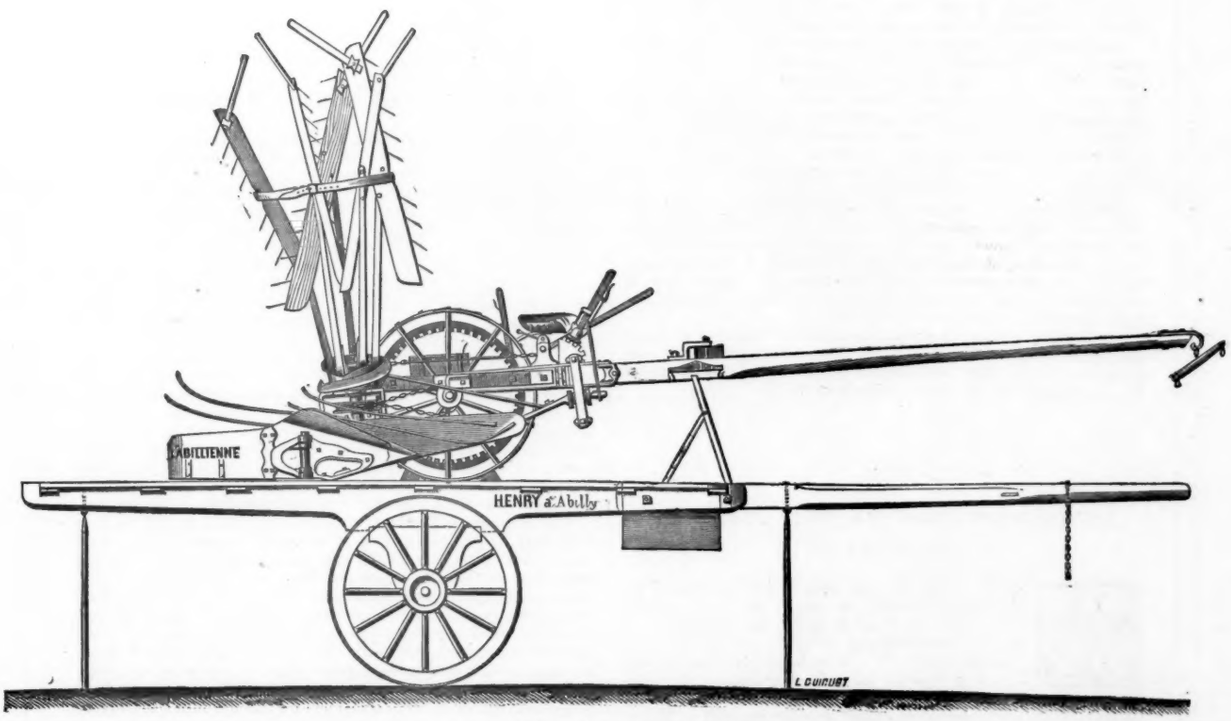
[3] See the "Practical Magazine," New Series, No. 3, March, 1875.

[1] *Sexton's Pocket-book for Boiler Makers and Steam Users.* By Maurice John Sexton. London: E. and F. N. Spon. 1875.

[2] *Progressive Lessons in applied Science. Part I. Geometry on Paper. Part II. Solidity, Weight, and Pressure.* By Edward Sang, F.R.S.E. London: E. and F. N. Spon. 1875.



PLAN OF REAPING MACHINE CAR.



CAR FOR REAPING MACHINES.

so to speak—the expansion of matter by heat, its change of shape by pressure, &c., thus leading him to "examine all the physical properties of matter which can influence our measurements or aid us in conducting them."

In the second part of the work, in which the measurement of solids is considered, the value of the practical method of the author is clearly seen, the student being advised to make his own models, for the preparation of which useful hints are given—a plan which cannot fail to aid very considerably in impressing the student with the facts with which it is necessary for his mind to be stored.

The two volumes together cover the main principles of geometry and their scientific applications, and deal, in addition, with some of the elementary principles of mechanics. They are written in pleasant and interesting style, so far as such subjects can be so treated, the reasoning is clear and close, and altogether the volumes are such as we can very warmly commend.

INORGANIC CHEMISTRY FOR ELEMENTARY CLASSES.[1]

THE whole purpose of this book is the "coaching" of students for the Science and Art Department examinations—and it is one of a class which, while no doubt serving admirably the purpose for which it is intended, cannot be regarded in any other light than a most objectionable one—failing in every way to impart a true knowledge of the subject of which it treats. That it has gone through six editions already is no more proof of its soundness or superiority, than the fact of Mr. Tupper's volumes of dreariness meeting with an extensive sale stamps their author as among the first poets of our era.

The book is constructed on a plan which, from the laudatory extracts appended to the volume, appears to have commended itself warmly to certain teachers of science classes. And at this we do not wonder, as it must relieve the teacher from the necessity of doing anything but hear his pupil recite from memory a series of short stock definitions, which may possibly enable him to answer the usual questions put at the examinations, but which cannot give him any knowledge of the science which will prove of real value to him.

The book contains no adequate recommendations to the student to exercise himself in practical work, and without this we feel confident that all attempts at acquiring a true knowledge of the science must fail, and the only result of the exclusive use of a work of this kind will be—when once the ordeal of examination is over—an utter confusion of ideas, even upon the most elementary principles of the science.

Nothing like a true scientific method of development of these principles is to be found from cover to cover; it is a cram book pure and simple; and, having said this, we cannot as we take it, express any stronger condemnation.

AN INTRODUCTION TO THE STUDY OF CHEMISTRY.[2]

ALTHOUGH, like the small work published by Messrs. Heywood, of which we have spoken above, this book is designed for candidates in certain examinations, it is by no means to be classed with it as a cram book pure and simple. It has a definite method of unfolding the principles of the science, and attempts to impart a real knowledge of them—not a mere power of repeating, parrot-wise, certain definitions, in order to be primed for replying to the questions set in particular examination papers. The importance of practising experiments is insisted upon, and the curriculum put forth by any particular examination is not strictly adhered to, although that of the London University Matriculation Examination receives special attention. This examination is, however, one which really offers no inducement whatever to the student to "cram" for it; if he does, we feel pretty confident that he will be "floored." Some hints to candidates under examination are given at the end of the book; they are sensible, and will be useful in giving the novice an idea of how to attack the paper which may be set before him, while they strongly deprecate any attempt at the objectionable system of "cramming."

In order to justify fully his title of "an introduction to the study," the author has avoided the use of symbols or atomic weights in the earlier portion of his work, introducing this at a considerably later stage than some other writers have done; and in support of this plan, which seems to us to be not without its advantages, he insists upon the importance of the student acquiring a knowledge of the concrete and practical before he ventures upon the abstract and theoretical departments of the subject, quoting the authority of Professor Bunsen and of Gay-Lussac in behalf of his views.

The subject of the book extends only to the systematic consideration of the non-metallic elements, treating indirectly of the more common metals which enter into combination with them. The few theoretical considerations that are introduced occur only in the second part of the work, and disputed theories, and others which have not yet received unqualified and universal approbation, are wisely avoided, those opinions only being advanced which have received the "public sanction of acknowledged authority." The work being now in its fifth edition, it is needless for us to do more than to indicate its special features to our readers, and to express our opinion as to its general usefulness to the student.

ELEMENTARY PRINCIPLES OF CARPENTRY.[1]

BY the student and the professional man alike, this revised re-issue of Tredgold's well-known and important work will be heartily welcomed. Such a re-issue has been much in request, and in its present form we have no doubt that its value will be still more widely recognized. The march of scientific knowledge, and the rapid development of the railway system, with other causes, have, as our author says, "contributed greatly to the introduction of new methods and to the multiplication of examples in the art of construction," and all these have tended "more or less to tax the ability and knowledge of the carpenter."

In addition to a general revision of the whole work, it has been necessary to re-write the articles on pillars, bridges, and timber, the numerous varieties of which latter that have been introduced of late years, and the valuable properties that many of them have been found to possess, such as that of resistance to the attacks of seaworms and insects, rendering this section a very important one. New sections on coffer-dams, scaffolding, &c., have been written, and many important plates and woodcuts have been introduced to elucidate them.

The completeness of the work as it now stands will be best indicated by a hasty glance at its chief divisions; these deal successively with the equality and distribution of forces, and the resistance of timber—under the head of Construction, floors, roofs, domes, partitions, centres for bridges, &c., are treated of, and scaffoldings, staging, gantries, coffer-dams, shoring, and strutting, wooden bridges and viaducts, joints, straps, and other fastenings are dealt with fully in the various sections devoted to them,—while the whole is supplemented by a most complete and exhaustive treatise on the different kinds of timber, their properties, qualities, uses, &c. Then follows a series of important and valuable tables for practical use, and last, but not least, a number of carefully executed lithographic plates, illustrating structures of the simplest kind, as well as some of the more elaborate details of parts of well-known buildings, bridges, &c. An admirable index gives to the whole a character of completeness, which we should be glad to see more general in works intended for scientific and practical men than it frequently is.

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[1] *Inorganic Chemistry for Elementary Classes, Designed chiefly for use in the Elementary Stage of Classes in connection with the Science and Art Department, South Kensington.* By W. H. Smith, LL.D., &c. and Alfonso Gardiner, Author of "Acoustics, Light, and Heat," &c. Seventh Edition. Manchester: John Heywood. London: Simpkin, Marshall, and Co.

[2] *An Introduction to the Study of Chemistry, designed for the use of Schools and Candidates for University Matriculation Examinations.* By F. S. Barff, M.A., &c. Fifth Edition. London: Groombridge and Sons. 1875.

[1] *Elementary Principles of Carpentry.* By Thomas Tredgold. Revised from the original and partly re-written by John Thomas Hunt. Second Edition. London: E. and F. N. Spon. 1875.